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THE SIXTY-INCH REFLECTOR OF THE MOUNT WILSON SOLAR OBSERVATORY.*

By E. A. FATH.

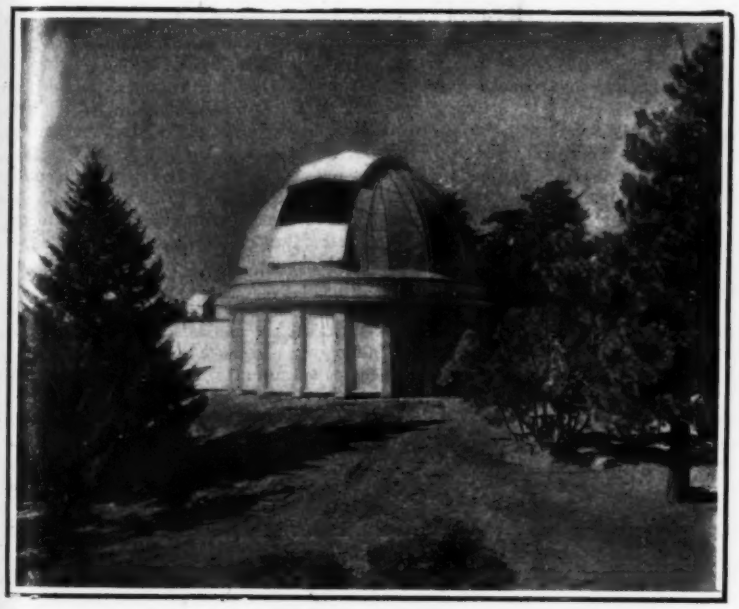
THE new sixty-inch reflecting telescope of the Mount Wilson Solar Observatory has been in operation for about one year. It is primarily a reflector of the Newtonian type with an aperture of sixty inches and a focal length of twenty-five feet. The outer section of the tube carrying the Newtonian plane mirror can be replaced by similar sections carrying convex mirrors which reflect the cone of light back toward the large mirror. Then by introducing a plane mirror in the path of the beam near the lower end of the tube to throw the beam out to the side it is possible to obtain equivalent focal lengths of 80, 100 or 150 feet. For direct photography either the 25- or 100-foot focus is used; for spectrographic work the 25-, 80- or 150-foot combinations are available.

The steel tube is of skeleton construction, exceedingly rigid and weighs only four tons. It is carried by a massive fork at the upper end of the polar axis. Most of the weight is taken off the bearings of this axis by means of an iron float fastened to it and buoyed up by mercury. The moving parts of the telescope weigh about twenty-three tons.

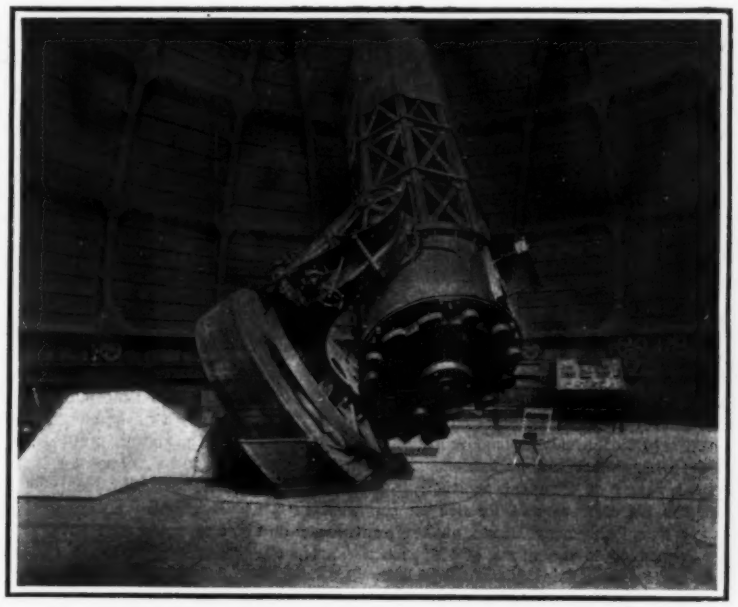
The driving clock, which stands six feet high, is of the Warner & Swasey type such as is used for the Yerkes and Lick refractors. There is, however, one important modification. Instead of the governor being connected with the driving shaft by means of the ordinary system of gears it is connected directly through a small worm gear. The weight for the clock consists of sixteen cast-iron disks, each weighing about one hundred pounds. The winding of the clock is automatic. When the weight is nearly down, it closes a circuit and an electric motor then winds it up. When the weight has reached the proper height, it breaks the motor circuit. The clock thus needs no attention throughout the night. The large worm gear which rotates the telescope is ten feet in diameter. When properly rated the clock runs very accurately. Frequently the guiding star will remain on the cross-wires of the guiding eyepiece for five minutes at a time.

The optical properties of the large mirror are of

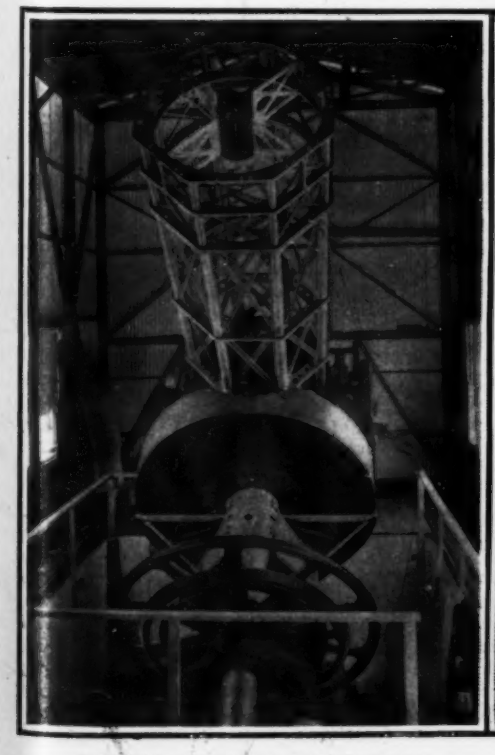
* Popular Astronomy.



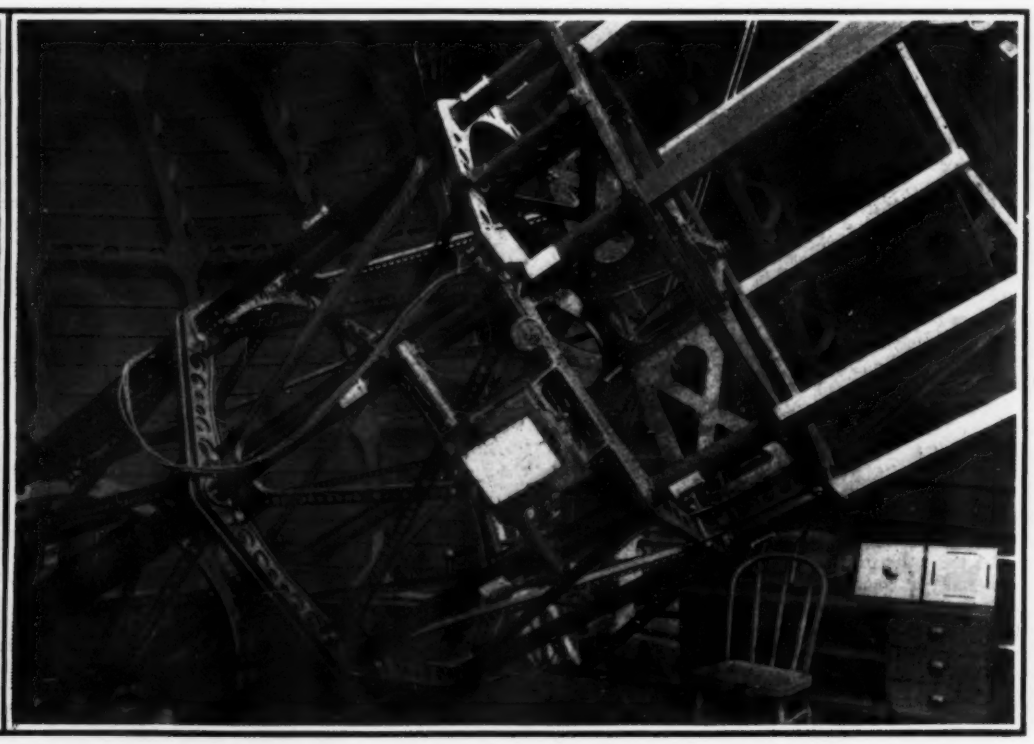
STEEL BUILDING AND DOME FOR USE OF SIXTY-INCH REFLECTOR.



SIXTY-INCH REFLECTOR MOUNTING IN DOME.



SIXTY-INCH REFLECTOR MOUNTING IN ERECTING SHOP.



DOUBLE-SLIDE PLATE-CARRIER IN PRINCIPAL FOCUS OF SIXTY-INCH REFLECTOR.

THE SIXTY-INCH REFLECTOR OF THE MOUNT WILSON SOLAR OBSERVATORY

the highest order. The surface is correct to about 0.000002 of an inch. This is 1/10 the wave length of sodium light. Under good atmospheric conditions star images measuring only 1.3 inches in diameter have been obtained on Seed "23" plates with exposures up to two hours in length.

The building and dome are built of steel throughout and rest on a concrete foundation. The walls are double with an air space of two feet between them and so arranged to permit a free circulation of air. The dome, which is fifty-eight feet in diameter, is covered, except in winter, with white canvas about two feet above the metal surface. It is found that in the summer this simple device to prevent the sun shining directly on the dome cuts in two the daily range of temperature within.

The building has two floors, the lower at the ground level, and the other, the operating floor, nineteen feet above this. The former is of cement and the latter of thin steel plates. The opening in the dome is sixteen feef wide, the shutter running back over the dome instead of opening to the side as in the usual type. The observing at the primary focus is done from a movable platform that can be raised or lowered along the curve of the dome opening. Electric motors are used for all movements of the telescope, dome and observing platform.

The changes of temperature referred to above have an appreciable effect on the performance of the telescope owing to the changes in the focal setting as the tube cools during the night. With the canvas cover over the dome this amounted to only 0.04 of an inch during the average night. This, however, was still too great, especially for long exposures running over several hours. In order to further decrease the effect an insulating chamber of woolen blankets was made to be placed over the lower half of the tube, the mirror, the float, etc. Radiation from the floor is prevented by mats of the same material. The opening in the tube where the covering surrounds it is closed by a tight-fitting wooden cover lined with felt. Under average conditions the daily range of temperature within the cover has been reduced to 2 deg. Centigrade (35.6 Fahrenheit). This in turn has reduced the change of focal setting to 0.02 of an inch. During long exposures the plate can be removed and the focus corrected at intervals so that the plate is never out of focus by more than one or two-thousandths of an inch. The method of focusing is simple. A carefully ground knife edge is placed across the center of the field and the image of a star at the center examined just as an artificial star image is examined in the optical shop. When the knife edge is at the focus of the mirror and is moved across the cone of rays, it causes the mirror to darken uniformly over its whole surface until all the light is cut off. This test is visual, the eye being placed close to the knife edge. By this method the focus can be determined with an accuracy of about 1/1000 of an inch in a minute or two.

A great variety of work is being undertaken with this telescope. At present it is being used for the photography of nebulæ and star clusters; the photography and spectrographic work on all the regions that can be reached that are included in Kapteyn's "Plan of Selected Areas"; spectrographic work on the brighter stars, star clusters and nebulæ and photometric work of various kinds.

Mr. Ritchey, who ground and figured the large mirror and designed the dome and mounting, is to be congratulated on the success he has achieved in completing such a great instrument, and we look forward to the day when the contemplated 100-inch reflector will be completed in the hope that it will prove even better than the sixty-inch.

SVEN HEDIN'S "TRANS-HIMALAYA."*

DISCOVERIES AND ADVENTURES IN TIBET.

THE special quest of Dr. Sven Hedin in his last and greatest journey of geographical exploration in Tibet was that hitherto unexplored range of mountains, which was believed to rise within the unsurveyed white patch of desert on the "Roof of the World" to the further side of the Tsangpo or Brahmaputra, behind the Himalayas. Although this immense chain, stretching for about 600 miles, is one of the mighty mountain ranges of the earth, and forms the northern watershed of the great Brahmaputra, as well as of the Upper Indus, yet its very existence, even, was largely the subject of conjecture.

A line of high peaks in this desolate region was first reported about 200 years ago by a party of surveyor-Lamas, who had been trained and sent out into Tibet by the Jesuits of Peking, under the patronage of the Emperor Kang-hsi; and the peaks, as located and named by these Tibetans, and rediscovered by recent travelers, figure on the rough map, published by D'Anville, in A. D. 1733. Brian Hodgson, in 1848, as the result of his inquiries in Nepal, depicted these peaks in his sketch-map as forming portions of a hypothetical range of mountains, stretching continuously from the Karakorum and Pamirs on the west to the Tengri Nor Lake near Lhasa on the southeast; and he assigned to it the name of "Nyenchen," after the name of the highest peak near its Lhasa end. In the map attached to Huc's travels, this range is also represented as an unbroken chain; and so, too, in Saunder's map of 1879 in Markham's "Tibet"; while Grenard, the companion of the ill-fated de Rhins, in 1899, indicates it conjecturally as a double range, which Col. Burrard, of the Indian survey, in his recent book on the geography of Tibet, has called the "Kailas Range," after the famous Mount Olympus of the Hindus, at its northern end. So great, indeed, was the need for the exploration of these mountains deemed to be that the president of the Royal Geographical Society declared a few years ago that: "In the whole length, from the Tengri Nor to the Mariam La, no one has crossed them, so far as we know" (a statement, by the way, not absolutely correct, as the pundits Nain Sing and A-K. and Littledale had crossed them) " . . . I believe nothing in Asia is of greater geographical importance than the exploration of this range of mountains."

This, then, is the range to which Dr. Hedin now assigns the appropriate name of "Trans-Himalaya," after having zigzagged across it by eight different passes, and after mapping out its contour in considerable detail.

More than this, the two handsome volumes in which Dr. Hedin tells the story of this great achievement differ from all his previous books on the "Forbidden Land" in possessing greater human and living interest. For the first time, after his many previous years of travel in that country, he has been able to penetrate beyond the desolate deserts and reach a portion of what he truly terms "Tibet proper, that is the part chiefly inhabited by a settled population." For this good fortune and for the more friendly treatment generally which he experienced at the hands of the Tibetans he is indebted directly to the amicable relations established with Tibet by the British mission of 1904, none the less real and genuine though cultivated at the point of the bayonet. These relations of friendship and respect, strengthened and cemented by the visit of the Grand Tashi Lama to India in 1905 to meet the Prince of Wales, have enormously increased the prestige of the European throughout Tibet and Central Asia. Thus, a section of Younghusband's mission with four British officers, unaccompanied by any escort of their own, but relying solely on the protection of the Tibetans, was able to pass in a friendly way through those inhabited districts of Tibet, two years before Dr. Hedin visited them; and several other Europeans have visited the Tashi Lama's palace and the western capital. In particular, Lord Minto, the Viceroy of India, to whom the author gratefully dedicates his book, "used his influence with the Tashi Lama so that many doors in the forbidden land formerly tightly closed were opened to me."

The start, under such favorable conditions, was made in August, 1906, from Ladak, by way of Kashmir, as the recent treaty with China absolutely prohibited Europeans entering Tibet across the Indian frontier, and could not be relaxed by the Indian Government even in favor of Dr. Hedin, much to his freely expressed vexation. He gave out that he was proceeding to Turkestan, but in the solitudes, a few marches out of Leh, he crossed the lofty Karakorum range and turned southward into the great elevated Tibetan desert, the Chang-tang. Here he pushed on through the stark solitudes, day after day for two months, surveying the country, without meeting a soul until he crossed the Trans-Himalaya near the capital of Western Tibet. The first nomadic herdsmen he encountered were friendly and acted as guides and supplied provisions and baggage animals. They, as well as their chief, informed him of the friendly passage that way of the British officers, saying that "now Europeans seem to be privileged to pass through the country." In a few days more, Tibetan couriers arrived with his European letters, which had been sent on by the British agent through the Tashi Lama, at the request of Lord Minto; and accompanying these letters, were welcome stores of European provisions, newspapers, books, etc., as presents from the British agent at Gyantse; and, most important of all, an official to guide and assist Dr. Hedin through that inhabited portion of Tibet to the Tashi Lama's capital.

Thereafter, writes our author, "the route was as free to us as the uninhabited Chang-tung had been. We should pass black tents daily, be able to buy all we want. We enjoyed unlimited freedom, and had not a single man with us as escort or watchman." Arrived at the capital, Shigatse, he says, "the priests welcome us with kindly good-tempered smiles," and he was installed as the favored guest of the Tashi Lama, the second of the "Living Buddhas," who received him cordially several times. This high honor which he procured through Lord Minto, proved so invaluable to Dr. Hedin, that, as he writes, "eighteen months later it came about that chiefs and monks said Bonpo Chimbo (great lord!) we know that you are a friend of the Tashi Lama, and we are at your service!" His Holiness, it is interesting to learn, has been a keen photographer since his visit to India, when he was initiated into the mysteries of the art by British officers. In his palace he has had a dark room fitted up, where the developing is done by one of the young priests who accompanied him to India. While halting at the Tashi Lama's capital, our traveler lightened his baggage by sending back to Europe, through the British officer at Gyantse, his survey records, note-books, photographic plates, rock-specimens, etc. Here, also, he witnessed the new-year's carnival and festivities, and was allowed to roam freely over the famous palace of the monastery of the Tashi Lama, a busy hive of four thousand ascetics; but, unfortunately, our author, through want of special knowledge, has not added anything to our information on these interesting subjects.

His stay at Tashilhunpo was brought suddenly to an end by the Chinese officials at Lhasa, who insisted on the Tibetans enforcing the treaty, so that Dr. Hedin was compelled to return forthwith to Ladak under a guard. On the way he succeeded in eluding his guard and made a detour across the Trans-Himalaya by two fresh passes; he also discovered a new western source of the Brahmaputra, and took a series of soundings over Lake Manasarowar, by means of his portable boat.

On return to Ladale, with characteristic pertinacity, he decided to make a second expedition back again to Tibet, in order to complete his partial exploration of the Trans-Himalaya, as he reflected that, "it was especially irritating to think that others might come here and rob me of these conquests." So with a fresh caravan, got together with the aid of the British officials, he plunged south once more through the terrible Tibetan deserts, and much astonished the discomfited Tibetan chiefs by his reappearance among them a year after they had got rid of him with such infinite pains. In this latter traverse, three more passes were surveyed, with the result, to quote the author's own words, that, "When I passed over the Trans-Himalaya for the eighth time at Surnge-la, I had the satisfaction of seeing all the old hypotheses fall down like a house of cards and a new ground plan laid down on the map of Asia, where before the blank patch yawned with its alluring "Unexplored." This mountain-system, it is remarked, cannot be called "a range," because it is a collection of several ranges, more or less parallel or branching off at various angles; Dr. Hedin, however, will find that somewhat similar features are displayed by the Himalayas themselves.

The narrative of the two years' strenuous journeyings for the survey of these formidable mountains, is written in a vigorous, direct style, which reflects the cheery optimism of this pioneer traveler as he pushed on undaunted, in the face of endless hardships and difficulties. It also shows him animating his men with something of his own abounding enthusiasm, without which, indeed, the exploration could never have been accomplished. The reader feels the swing of the caravan moving through the pages, with the thrill of reality and a pervading sense of danger ahead; though to many readers the repetition from day to day of the details of camp routine, and the reiterated records of the grim struggles of the men and the sufferings and painful deaths of the dwindling baggage animals, will doubtless make somewhat monotonous and unpleasant reading after a time.

Besides the geographical record, so important in it-

* "Trans-Himalaya, Discoveries and Adventures in Tibet." By Sven Hedin. With 300 illustrations from photographs, water-color sketches and drawings by the author and ten maps. In two volumes. Vol. i., pp. xxiii. + 430; vol. ii., pp. xvii + 441. (London: Macmillan & Co., Ltd., 1909.)

self, and the camp episodes, there is little else that is new. Remarkably few references occur in respect to natural history; scarcely any mention or passing recognition is made of wild animals, or plants, or minerals, such as we expect in the journal of a scientific traveler; and the few remarks which occur in regard to the people and their customs exhibit a lack of familiarity with authentic sources of precise information, and the well-known researches of Rockhill and others. Incidental reference is made to a collection of rock-specimens, the description of which by specialists is promised along with the detailed maps, which will doubtless be accompanied by an analysis of other objects collected, though no mention is made of them. The young Indian elephant of the Tashi Lama, we are told, "is the only one of his species in the whole country"; but the Talai Lama, we know, has (or had in 1904) a much larger tusker, a present from the Sikhim raja, which had survived the arctic winters of many years at Lhasa, and was housed in a grove near the British mission camp outside that city in 1904. "A *Bod* or Buddhist" is spoken of as if the two terms were equivalent, whereas the former means a Tibetan or inhabitant of *Bod* or Tibet. The "*Bothiyas*" (*sic*) are described as "a mixed people sprung partly from Indian and partly from Tibetan elements," whilst in reality, "Bothiya" is merely the Indian designation of the Tibetan race or people of *Bod*. A want of precision in the spelling of several of the vernacular place-names is noticeable in a professedly geographical work, thus "Sekiya" invariably occurs in the text for the well-known monastery and sect of Sakya or Saskyas, and "Yeretsangpo" for the Yaru (or "upper") Tsangpo; and many of the names are spelt phonetically according to no regular system. To say "Hor or Bod-yul" is equivalent to saying "Turkish or Tibet." In regard to the term used for the great Manasarowar Lake by D'Anville in his old map, namely "*Ma-pama Talai*," or Ma-pama Lake, Dr. Hedin gives "Ma-vang" as the correct form, but this latter is merely the vulgar vocalization of the name, which is spelt and properly pronounced as "*Ma-pàm*"; and our author sagely states that "D'Anville might have added that the Chinese Talai or Dalai means ocean," and that it was used to imply that this particular lake was larger than the other neighboring lakes mentioned in his text. This, however, is not correct. "Tālai" is *not* Chinese, but a Mongol word, and it is applied to all the lakes in that neighborhood, as well as throughout the Northern Himalayas, irrespective of their size; and in the abbreviated form of "*Tāl*" it was imported into Northern India by the Moghal section of the Mongols, and is now naturalized there as the current vernacular name for a lake. Deficiencies of this kind, however, can be corrected in another edition, and in no wise belittle the outstanding importance of Dr. Hedin's splendid geographical achievements.

These attractive volumes, with their wealth of sketches and beautiful photographs, deserve nothing but praise, and form a fitting record of Sir Sven Hedin's magnificent pioneer work amongst one of the most forbidding mountain ranges in the world. This work, too, is of such importance to Indian hydrography as to have gained for its author, amongst other well-earned honors, a knighthood of the Indian Empire. It is also pleasing to observe that his men have not been forgotten, for the thirty-seven Asiatics who followed the explorer faithfully through Tibet, and, as the author generously admits, "contributed in no small degree to the successful issue and results of the expedition," have been rewarded with gold and silver medals, bestowed by the King of Sweden.—Nature.

HALLEY ON THE AGE OF THE OCEAN.

CHEMICAL DENUDATION IN RELATION TO GEOLOGICAL TIME.

BY GEORGE F. BECKER

EDMUND HALLEY was a very great man. He was not only the first to predict correctly the return of a comet, that which is now known by his name, but also—before Newton had announced his results to any one—arrived at the conclusion that the attraction of gravitation probably varied inversely as the square of the distance. While these and other important achievements of his are well known, it seems to have been forgotten that Halley devised a method of determining the age of the ocean from chemical denudation. Indeed, I find no mention of Halley in the indices of some of the most authoritative works on geology and geochemistry, while it is evident that neither Mr. T. Mellard Reade * nor Mr. J. Joly † was aware of a predecessor in this important field. It was almost by accident that I came across Halley's paper read before the Royal Society in 1715, extracts from which are given below.

Halley recognized that the method as he proposed it was almost impracticable, but writing as he did twenty-eight years before Lavoisier's birth, he could hardly have guessed that accurate analyses of river waters, whose solvent action he so clearly describes, would ever become not merely possible but easy. It is very interesting to note that Halley's reasoning is strictly "uniformitarian" while he recognized the tendency involved to a maximum estimate.

Subject to this same limitation (extended to other features besides an original saltness of the sea), Mr. Joly's method of determining the rate at which the accumulation of salt in the ocean takes place from the analysis of river waters is perhaps the most important means now available for an estimate of the antiquity of the stratified rocks, because it is the simplest and least open to question. To my thinking the fact that his train of reasoning coincided with that of the great astronomer only adds to the credit due Mr. Joly.

A great amount of work has been done of late years on the composition of river waters, much of it incited by Mr. Joly's memoir and undertaken with the purpose of improving the data for such a determination of the age of the ocean. Within a few months it will be practicable to make known the results of a revised estimate founded upon data far more ample than those at the disposition of Mr. Joly eleven years ago. Mr. F. W. Clarke is now engaged in preparing this estimate.

The subjoined extracts from Halley's paper ‡ cannot but interest all lovers of natural science:

"On the Cause of the Saltness of the Ocean, and of the Several Lakes that Emit no Rivers; with a Proposal, by Means Thereof, to Discover the Age of the World.

"There have been many attempts made, and proposals offered, to ascertain from the appearances of nature, what may have been the antiquity of this globe of earth; on which, by the evidence of sacred writ, mankind has dwelt about 6,000 years; or according to the Septuagint above 7,000. . . . This inquiry seeming to me well to deserve consideration, and worthy the thoughts of the Royal Society, I shall take leave to propose an expedient for determining the age of the world by a medium, as I take it, wholly new, and which in my opinion seems to promise success, though the event can not be judged of till after a long period of time; submitting the same to their better judgment. What suggested this notion was an observation I had made, that all the lakes in the world, properly so called, are found to be salt, some more, some less than the ocean, which in the present case may also be esteemed a lake; since by that term I mean such standing waters as perpetually receive rivers running into them, and have no exit or evacuation. . . .

"Now I conceive that as all these lakes receive rivers, and have no exit or discharge, so it will be necessary that their waters rise and cover the land, until such time as their surfaces are sufficiently extended, so as to exhale in vapor that water which is poured in by the rivers; and consequently that lakes must be larger or smaller, according to the quantity of the fresh they receive. But the vapors thus exhaled are perfectly fresh; so that the saline particles brought in by the rivers remain behind, while the fresh evaporates; and hence it is evident that the salt in the lakes will be continually augmented, and the water grow salter and salter. . . .

"Now if this be the true reason of the saltness of these lakes, it is not improbable but that the ocean itself is become salt from the same cause, and we are thereby furnished with an argument for estimating the duration of all things, from an observation of the increment of saltness in their waters. For if it be observed what quantity of salt is at present contained in a certain weight of the water, of the Caspian Sea, for example, taken at a certain place, in the driest weather; and after some centuries of years the same weight of water, taken in the same place, and under the same circumstances, be found to contain a sensibly greater quantity of salt than at the time of the first experiment, we may by the rule of proportion, make an estimate of the whole time wherein the water would acquire its present degree of saltness.

"And this argument would be the more conclusive, if by a like experiment a similar increase in the saltness of the ocean should be observed; for that, after the same manner as aforesaid, receives innumerable rivers, all which deposit their saline particles therein; and are again supplied, as I have elsewhere showed, by the vapors of the ocean, which rise from it in atoms of pure water, without the least admixture of salt. But the rivers in their long passage over the earth imbibe some of its saline particles, though in so small a quantity as not to be perceived, unless in these their depositories after a long tract of time. And if, on repeating the experiment, after another equal number of ages, it shall be found that the saltness is further increased with the same increment as before, then what is now proposed as hypothetical, would appear little less than demonstrative. But since this argument can be of no use to ourselves, it requiring very great intervals of time to come to our conclusion, it were to be wished that the ancient Greek and Latin authors had delivered down to us the degree of the saltness of the sea, as it was about 2,000 years ago; for then it cannot be doubted but that the difference between what is now found and what then was, would become very sensible. I recommend it therefore to the society, as opportunity shall offer, to procure the experiments to be made of the present degree of saltness of the ocean, and of as many of these lakes as can be come at, that they may stand upon record for the benefit of future ages.

"If it be objected that the water of the ocean, and perhaps of some of these lakes, might at the first beginning of things, in some measure contain salt, so as to disturb the proportionality of the increase of saltness in them I will not dispute it; but shall observe that such a supposition would by so much contract the age of the world, within the date to be derived from the foregoing argument, which is chiefly intended to refute the ancient notion some have of late entertained, of the eternity of all things; though perhaps by it the world be found much older than many have hitherto imagined."

* "Chemical Denudation in Relation to Geological Time," 1879.
† Trans. R. S. Dublin, vol. i., 1899, p. 23.
‡ Phil. Trans., vol. xxix., 1715, p. 296.

The Boston Elevated Railway Company has begun to hold regular monthly meetings of the chief engineers of its power stations, corresponding to the meetings which the company also holds with its division superintendents and car-house foremen. It is proposed to appoint subjects for discussion which will lead toward a reduction in operating costs and the improvement of the power station service in general. Tabulations of the cost of production at the different plants will be prepared regularly, including comparisons of the current performance of each station with previous operation, and the contrasting of conditions and operating results in the several plants. The company at present operates eight steam and two gas engine plants of a normal capacity of 50,000 kilowatts. The operations of these stations are under the jurisdiction of a superintendent of power stations, reporting to the chief engineer of motive power and rolling stock. At the initial meeting in April a general discussion of operating conditions in the different plants was held, after which the purpose of the meetings was explained by the chief engineer of motive power and rolling stock.

The purchase of coal on its heating value by the United States government is reported, by the Technologic Branch of the United States Geological Survey, to have effected a saving of $200,000 in the annual fuel bill of the government, which now aggregates about $1,000,000. At the present time, forty departmental buildings in Washington, more than three hundred public buildings throughout the United States, the Panama Railway, navy yards and arsenals are buying their fuel supplies on specifications fixing the amount of ash and moisture. The actual quality and value of the coal delivered is determined by analyses of representative samples and deductions are made from the contract price, in case of deliveries of poor coal, proportionate to the decrease in heating value. Premiums are paid for any decrease of ash greater than 2 per cent below the specified amount at a rate of 1 cent per ton for each per cent, and deductions are made at an increasing rate for each per cent of ash in excess of 2 per cent above the standard.

THE ANCIENT AND THE MODERN ABACUS.

THE OLDEST COUNTING MACHINE.

BY DANIEL ARTHUR.

THE ancient decimal bead frame is still in actual use side by side with the very latest adding and listing machine, which we might call a modernized abacus. This modern decimal calculator with its printing press attachment and its electrical power plant almost thinks, yet it is fundamentally the same as the Japanese "Soroban," the Roman Abacus and the Chinese "Swan Pan" (sometimes called "So Pan"). Abacus meant originally a sort of table, bench or board. Then it became a game board ruled off in squares, on which disks were moved, giving them value of location. "Swan Pan" in its abbreviated derivation literally means playing the bamboo. "Swan" stands for bamboo and "Pan" means play. The name seems to have developed quite naturally, as the little rods on which the balls or beads slide are made from young bamboo stems. Perhaps if our Western ear could catch the sweet commercial music of the clicking balls with the exact sensations recorded through the oriental ear, we would come nearer to the full understanding of industrial peace.

The "Swan Pan" is of various widths, some having few and others many bamboo rods. The more numerous they are the greater the capacity of the frame. Fig. 1 shows a fifteen-rod or fifteen-place "Swan Pan," which is about an average size for general use. The highest whole number that can be set on this one is 999,999,999,999,999. In this illustration the single counter moved up to the cross bar is the only bead which stands for anything, all the other fourteen rods or columns are set blank or assumed ciphers. This one bead means one hundred trillions in its full value sense. The "Swan Pan" is quite frequently confounded with the bead frames used in our primary schools. This is a gigantic blunder, as the former is a mathematical device of almost unlimited range, while the latter is an aid in teaching children to count.

Fig. 2 illustrates some of the steps of centuries, or the evolution from the counting tools of nature (hands) to this "Swan Pan" which still survives and which is the parent of the complex machines of to-day.

Before proceeding, however, it might be well to correct another more or less popular error, that of calling the fingers the origin of the number concept. This is not the case.

In fact man was well advanced in the world before he could conceive of a number as great as the count of one of his hands. Prof. Conant, in his very complete work on the origin of number words, brings this point out very clearly. He shows that the number concept began with one. Then the mind grasped something like one and two. Names were given to as small a radix as this, names which translate into "one" and "many." He shows that some savage tribes do not use names for numbers above three. All this goes to show that man was well advanced in the world before he could master counting tools as complicated as his hands. Hands and feet count or "scores" coming much later. This early development of number concept (less than 5 or 10) is mentioned here only to show that it is an extensive study in itself. The object of this article is to connect the hand symbols with the "Swan Pan" and the "Swan Pan" with the modern complex machine, and then to show that all three of these methods are in use to-day in our large cities for the transaction of regular business.

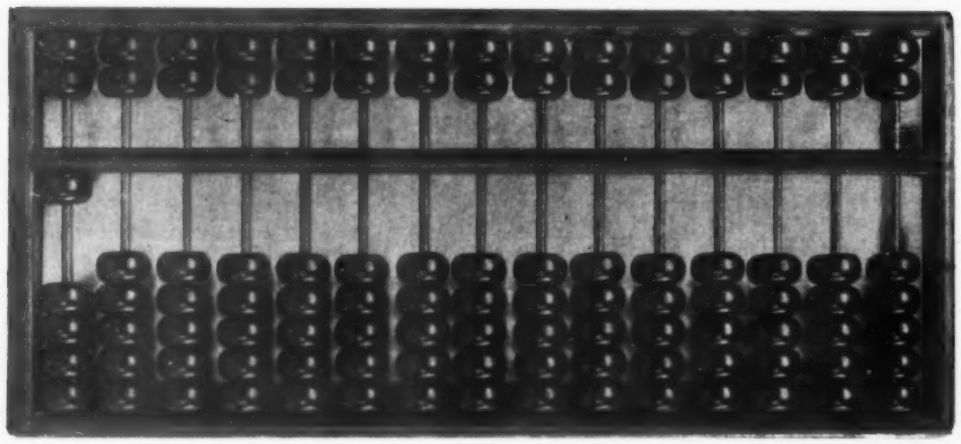


FIG. 1.—CHINESE SWAN PAN SET AT ONE HUNDRED TRILLIONS.

The first column in Fig. 2 illustrates the early self-evident symbol hand count, and to avoid complication we will not go into too much detail such as different number meanings indicated by clapping the hands, or holding them in vertical or horizontal position or upside down, touching certain joints in the fingers, etc. These varieties would fill a book. We take the simple horizontal form which makes the forefinger of the left hand stand for one. The second column shows the natural word meaning of these symbols. Many early peoples gave names to decimal numbers which were actual descriptions of the finger operations. For example, Prof. Conant draws our attention to the Eskimos of Point Barrow. Their name for seven is "Twice on the next." Six is named "Five and one on the next." Another tribe gives the name "Double finger" to the number two; another well advanced tribe has this name for a thousand, "The fingers all the fingers times all the fingers," which is intended to mean 10 times 10 times 10, or 10 x 10 x 10 equals 1,000. These examples will suffice to show that some of the first names given to the hand symbol numbers were literal descriptions of the symbol. One of the involved names was "All but one held up with the rest." This was a name given to nine, which means just the same thing as shown in the primary word column of Fig. 2. The next step after giving a word name to a hand symbol was to construct a condensed and manageable sign for the number, a stroke for every finger or groups of dots like those found on dominoes came first. This was soon found too cumbersome for the larger numbers, so it gave way to a special character or sign for a completed hand and another for two completed hands. The columns marked ancient and modern might more properly be called recent form and present form.

Let us first refer to the older form of Chinese numbers and note how truly descriptive they are: 1, 2, 3, and 4 are fingers pure and simple; 5 came very naturally. Try it yourself. Just hold up your left hand before you and trace a line down your thumb, then make a circular sweep around the palm and out to the tip of the forefinger. The result is such a perfect Chinese five that it was left unchanged when the last modification took place. For 6, 7, 8, and 9, the completed hand is indicated by a vertical stroke and underscored by the finger strokes, thus making self-evident number signs. Then follows the early form for ten, which is a cross like a crucifix, and is intended to represent a man. The vertical line represents a man's body and the cross bar his outstretched arms. The bar originally terminated in sets of elementary fingers, as shown in the first column. It is interesting to note that this cross is now used in China as one of their words, meaning completeness, as well as a sign for number ten. It is also interesting to note that the word "complete" is the name for ten in another part of the world. As ten is such a star number in the decimal system it might be in order to mention some of the many names given to it. Among those are "Half a Score," "Man Without Feet," "One Man of Hands," "One Man," "Double Hand, "All the Fingers," "Finished on Each Side," "Ended Both Hands," "Hand Hand," "Second Hand Fingers," "Two Series," "Second Five," "Half a Man." The last mentioned name for ten is based on the whole man being twenty (hands and feet). When we find a tribe with "one man" as their name for number ten we are sure this same tribe has no special name for twenty such as "Score."

Returning to the Chinese numbers, the modern ones, that is to say, those in use to-day for bookkeeping, it will be noticed that numbers 1, 5, and 6 remain unaltered, while 2 and 3 have the stroke lengths varied, as shown, so as to individualize them. This same change is made on the digit strokes of 7 and 8. Four is changed to a letter X, meaning one hand less one finger. Nine has developed into a combination or composite character made up from 4 and 5, while 10 has become a cipher. This in my opinion is the most important and far reaching step forward ever taken in number construction. It would be impossible to overestimate the value of this gigantic step. The introduction of the cipher or the sign for blank space cleared the track of all obstructions with one sweep, and made our decimal system complete, compact, logical and limitless. The cipher is of course a child of the "Swan Pan," and now that it is in successful operation we can see that an assumed cipher existed on

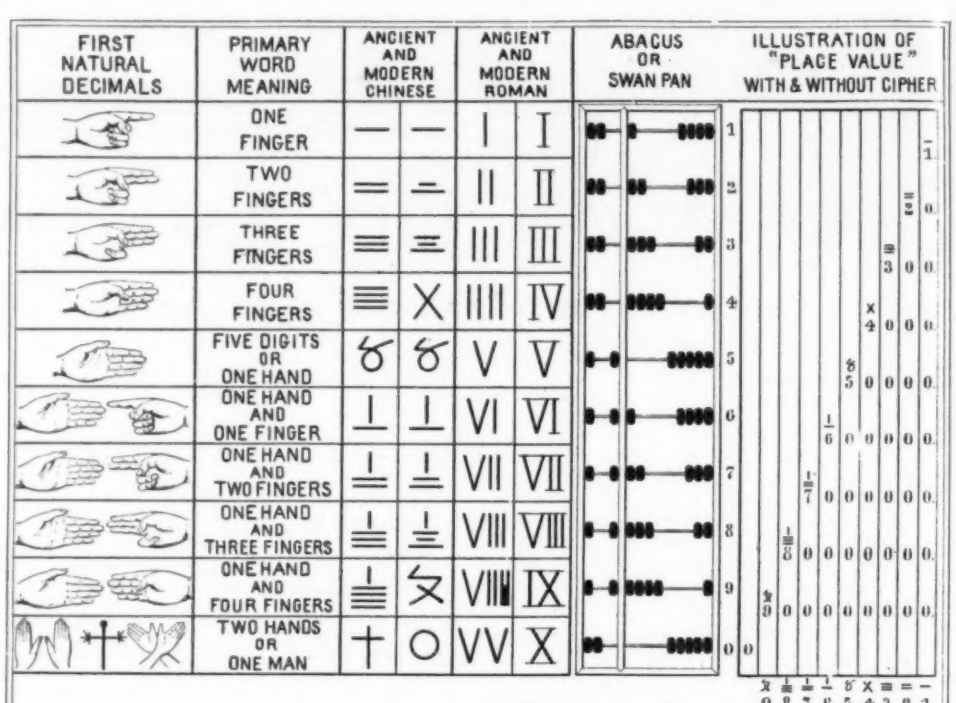

FIRST NATURAL DECIMALS
PRIMARY WORD MEANING
ANCIENT AND MODERN CHINESE
ANCIENT AND MODERN ROMAN
ABACUS OR SWAN PAN
ILLUSTRATION OF "PLACE VALUE" WITH & WITHOUT CIPHER
ONE FINGER
TWO FINGERS
THREE FINGERS
FOUR FINGERS
FIVE DIGITS OR ONE HAND
ONE HAND AND ONE FINGER
ONE HAND AND TWO FINGERS
ONE HAND AND THREE FINGERS
ONE HAND AND FOUR FINGERS
TWO HANDS OR ONE MAN
9 8 7,6 5 4,3 2 1.

FIG. 2.—SOME STEPS OF CENTURIES IN DECIMAL EVOLUTION.

this little frame for centuries before some one knew enough to transfer it to a written record. To make this point a little clearer, refer to Fig. 1. To transfer his one-hundred trillions to a written record the older Chinese method was to write one and follow it with a complicated character which meant hundreds of trillions. Its transfer to paper was accomplished by using only two characters, one and a qualifier. But let us see what happens when a comparatively small but mixed number, like 7,426, is transferred from its four decimal columns of the "Swan Pan" to the account book by the old method. Instead of its proper four places it occupies eight places on the book—7 was followed by a character standing for thousands; then came 4 followed by the hundreds character, then 2 followed by tens and 6 qualified with a unit sign. The cipher cured all this long hand complication.

The evolution of Roman numerals is quite similar to the growth of the Chinese except that hands were held in vertical instead of horizontal position; I, II, III, IIII being natural vertical finger strokes. The V for five (whole hand) being naturally formed by thumb and forefinger. A whole hand (V) and one finger (I) for six, and a hand (V) and four fingers (IIII) for nine are true nature signs. The same remark applies to double V for 10 (VV).

The condensed form now used, which is called modern in the illustration, converts the double V into the letter X for ten, and nine becomes an incomplete example in subtraction. X less I, or 10 less 1, and by the same Roman formula four becomes 5 less 1. Roman numbers have never been written in a strictly decimal order, although they are decimally constructed and have been used correctly on the Roman abacus. They could be brought into complete decimal order by the use of a cipher, but this is now out of the question, as they are not of a form that admits of rapid work; in fact they are kept alive only for dating purposes and the like.

The older form of Roman numerals shown here are still to be found on old clocks and calendars and on zodiacs.

We now come to the illustration of the "Swan Pan" (Fig. 2) drawn end up for convenience in description (normal position is flat on table or counter as in Fig. 1). The drawing shows a ten place frame which is capable of receiving a number as high as 9,999,999,999. The whole number set down by the beads as drawn is 987,654,321. The reason this number is chosen is that it indicates all of the different ball settings (1 to 9) in consecutive order beginning with one on the top down to nine on the next to lowest rod. The bottom rod is set blank, or on cipher. If all ten rods were thus set, that "Swan Pan" would be clear of figures and ready for an operator. The five balls in the wide compartment are digits, while the two balls in the narrow compartment are hands, each of which is of course five times the value of a digit ball. The Arabic numbers opposite each rod indicate the digital number set on each rod. For convenience let us refer to the five balls as fingers and the two balls as hands. A finger set against the partition bar counts 1, while a hand set against the bar counts 5. Let us follow the settings as they are: 1 finger to bar = 1, 2 fingers = 2, 3 fingers = 3, 4 fingers = 4. 1 hand to the bar = 5. 1 hand and 1 finger to the bar = 6. 1 hand and 2 fingers = 7. 1 hand and 3 fingers = 8. 1 hand and 4 fingers = 9. Now we could put down 10 by setting two hands to the bar or one hand and 5 fingers, but as the decimal place value system prohibits ten on a single rod or column (it being a two place number), we have set it 0 as above. This completes the lesson so far as setting down digits is concerned. When one grasps the idea properly that the two balls are hands and the five balls are fingers and thumb, and that there are no more than ten combinations of these, all of which are shown on the frame, the matter will seem very simple. In other words, the operator transfers the hand pictures of the first column to the ten rods of beads.

Now we are ready for the next and last step: Let us assume that the rods of a "Swan Pan" are columns ruled on paper on which we can write numbers. We are at liberty to consider all the columns whole numbers beginning with units on the right followed toward the left by tens, hundreds, thousands, etc., or we can consider that the two places on the right are units and tens of cents followed toward the left by units and tens of dollars. In other words, we can divide the columns or rods into whole numbers and decimal fractions and this imaginary decimal point can be placed anywhere we elect. We may even divide the "Swan Pan" and set down two sums, using say five rods on one part of the frame to put down $354.26, assuming the decimal point to separate dollars from cents. Then on the other end of the frame set down 248 bags of rice or bushels of potatoes. On very wide frames of over 20 rods, something like the following can be set down: 18 pounds of tea at 85 cents per pound equals $15.30. Of course the actual figures set down on the frame would be 18, 85, 153. The Chinese bookkeeper would know that his first figure meant pounds of tea, second figure hundredths of a dollar, and that the last figure was his total value, or 15 3/10 dollars.

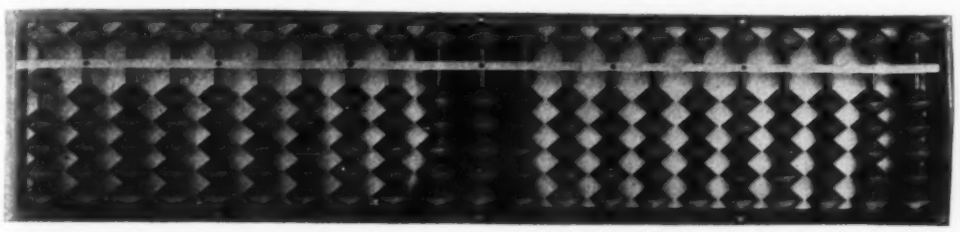


FIG. 3. JAPANESE SOROBAN SET AT 100,000,000,000,000,000,000.

In the ten vertical spaces or columns which illustrate the place value of figures set on the "Swan Pan" in Fig. 2, we are assuming that the number is a whole one, that the one finger is a unit, the two fingers 20, three fingers 300, and so on, making the total 987,654,321, which is given in Chinese numbers at the bottom as well as in Arabic. Chinese place value numbers are also shown in the columns above the Arabic.

Fig. 3 is a reproduction of a Japanese Soroban of 21 rods or columns capable of receiving the almost unthinkable number 999,999,999,999,999,999,999. The Chinese name for a number one-tenth the size of this is Woo Leang So or infinite number. Sir John Bowring, in his book "Decimal System," tells us that 1 followed by 16 ciphers is called Hang Ho Sa, meaning the sands of the Hang River. These innocent-looking little frames can therefore take care of figures up to the astronomical requirements.

On this Japanese Soroban it will be noticed that there are the same 5 digits in the lower compartment, but only one row of hands in the upper place. This is a step in advance of the Chinese, as no use of the second row of hands can be made in a strictly decimal operation. They might have even gone farther and left off the lowest row of fingers, for they are never used in decimal calculations. Note that in all the possible settings of the balls as shown in Fig. 2 none of the top hands or lower fingers ever leave the outer frame. I recently tried an interesting experiment on native Chinese bookkeepers. None of them could use the "Swan Pan" from which I had removed the unnecessary balls, but on another where I had locked these two rows with an unseen wire they went through all ordinary operations without discovering the locked balls. I might say, however, that the Chinese use the "Swan Pan" occasionally for calculations in land measure in which the decimal scale is not used.

Fig. 4 shows combinations of ball settings from 1 to 15 in which all the balls are used.

The use of the "Swan Pan" in this way is not quite legitimate, and the Japanese were a little quicker in seeing this point, but did not go quite far enough while they were improving their Soroban. The Japanese frame is much smaller and more compact than the Chinese, and instead of large, cherry-shaped beads, they use small sharp edged buttons. The distance these buttons slide is also much less than Chinese practice. It therefore takes sharper eyes to operate and quickly read the Soroban. Even with the wide spaces of the "Swan Pan" the quickness of the native in grasping a large number at a glance is astonishing to the Western observer, but with the small buttons and narrow spaces of the Soroban it is still more remarkable. The speed of an Eastern expert is almost unbelievable, and the percentage of error almost a vanishing quantity. In fact it is so unusual for a Chinese bookkeeper to make a mistake on his "Swan Pan" that his brother Chinamen count the rare occurrence as an intentional move on his part to deceive. I have made many tests of speed between experts on the "Swan Pan" and experts with a pencil, and the beads usually won, not only on speed, but also on accuracy.

The "short cuts" which an expert can use on these little bead frames are many and for certain kinds of decimal problems he can even beat the speed of the very latest adding machine (what I call the modern abacus). In simple sums of addition the modern adding and listing machine is bound to lead in accuracy against the ancient frame for the reason that when the list of items to be added is checked off as the ones intended, the footing or sum is bound to be correct unless the machine is broken. That is to say the human element is practically eliminated. In the case of the Japanese Soroban or the Chinese "Swan Pan," it is all a question of personal skill. These frames are ruled columns, so to speak, on which decimal sums can be quickly set down or rubbed out. Sums can be increased by addition or multiplication or reduced by division or subtraction. Each click of a bead means one figure rubbed out and another set down. When the last ball of any example is clicked there is nothing more to do, there is the answer.

In conclusion I would repeat that it would be hard to find a more striking example of the long and useful life of an old invention than the "Swan Pan." To see it working with its very latest relative (the modern adding and listing machine), speaks volumes regarding the broad difference between the oldest existing empire (China) and the newest power (United States). If the reader wishes to see the original "finger abacus" still in active use, some of the open air markets will best serve the purpose. The now famous "curb market" of New York city is as good an example as any. Complicated stock quotations, bids and contracts are handled there by finger symbol signs. Large figures and fractions are flashed from the street to upper-story windows and back again; each group of brokers using his own privately constructed code, the varieties of which seem almost endless. We, therefore, find the three great stages of decimal development working in harmony in the 1910 A. D. battle of life.

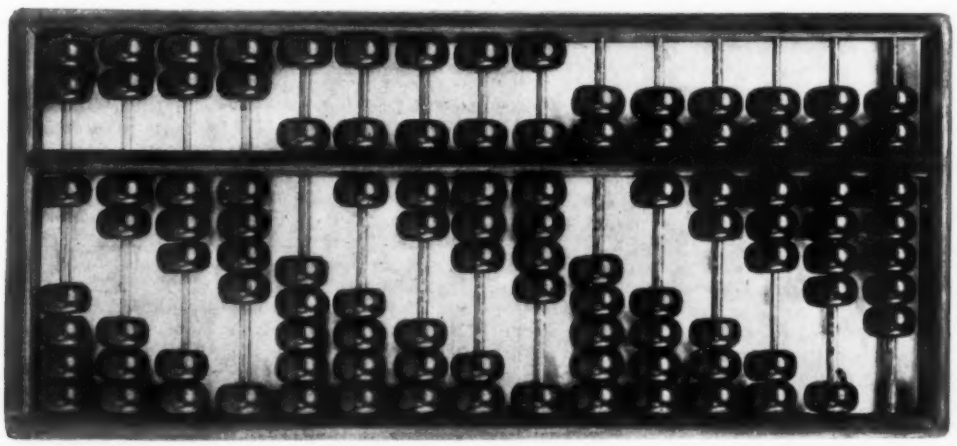


FIG. 4.—SWAN PAN BEAD SETTINGS 1 TO 15 AS USED BY CHINESE LAND SURVEYORS.

According to the Electric World, during recent tests of wireless telegraphy made with apparatus on board the scout cruisers "Salem" and "Birmingham," which were 1,000 miles from each other, and 1,000 miles from the high-power wireless station at Brant Rock, Mass., there were serious interruptions in the communications between the two ships and the shore station. A fierce storm was raging at the time of the tests, and, in spite of the interruptions, the apparatus was not considered a failure. Arrangements are to be discussed with a view to making further tests under more favorable conditions. During the next test the ships will be stationed about 2,000 miles from Brant Rock. This will necessitate one being near Trinidad, and the other 1,000 miles out from the South American coast. The most exhaustive test will be the placing of the ships on the African coast, 3,000 miles from Brant Rock and 1,000 miles apart. If these tests are successful, a tower 100 feet higher than the Washington monument, which is 555 feet in height, will be erected in Washington for communication with ships over a distance of 3,000 miles.

STORY OF THE "POURQUOI-PAS."

THE FRENCH ANTARCTIC EXPEDITION.

BY DR. JEAN CHARCOT.

On leaving Deception Island (latitude 62 degrees 55 minutes south) we made our way to Port Lockray, where we commenced our work. From here I made a trip of observation with Godefroy and Gourdon to Wandel in order to study the lay of the ice, which would save both coal and time. This little journey of forty miles was exciting enough and the final result of it was satisfactory. Some days later we arrived with the "Pourquoi-pas" at Wandel; we had bad weather on the way, with a strong northeast wind. The creek was rather small for our vessel; we had not had the time to install a satisfactory barrier, and the small ice did not protect us. For a week we were in danger there—unable to come out, assailed by enormous ice blocks, which had to be fended off or lashed up night and day. The photographs clearly describe our condition.

On January 1st Godefroy, Jacques, Gourdon and I made a reconnaissance to find a better shelter, when we found, at Petermann Island, the harbor which we named, in honor of the day, Circumcision. A few days after we brought the "Pourquoi-pas" round, having escaped from Wandel without suffering any serious damage by gently wriggling round the icebergs. I set out the same day with Godefroy and Gourdon to explore the south, chiefly to climb some eminence to see whether we had any channels to pass with the "Pourquoi-pas" between Bisco Islands and the coast. As we reckoned upon returning the same day we had taken neither supplies nor change of clothes. Our mission was easily fulfilled and we saw that the coast was blocked, but when we wanted to retrace our steps we found that our path was quite blocked by the ice. During a four days' blinding snowstorm we struggled to liberate ourselves—I will pass over the details of that trial. We were in peril of succumbing from hunger and cold; on the fourth day we shouldered our traps and determined to attempt some vulnerable part of the ice cliffs, whence our signals might be observed by our comrades, when the "Pourquoi-pas" came to our rescue, skillfully guided by Bongrain and Rouch, whose performances on the siren could be heard through the fog and snow.

On the journey back, unfortunately, the vessel stranded violently upon one of the innumerable reefs level with the water and we had to unload. After three days and three nights incessant labor we got her off again. But we had to leave behind a large piece of her prow, and it was with the vessel in this state that we accomplished the whole of our expedition.

From Petermann Island we went toward the south, skirting the coast and completing the chart of the "Français." We found the bay which was marked by Pendleton, the American whaler, and discovered to the north of Adelaide Island a large bay, which we have since named Matha Bay. We next took hydrographic observations of Adelaide Island, which has a very peculiar configuration. But instead of being eight miles in length as is generally supposed, the configuration has a length of seventy miles. South of Adelaide, in a region neither explored nor ever seen, we discovered a great bay, which I have named Marguerite. We entered here, despite the reefs and compact ice, and anchored at a little isle which I named Jenny, after Bongrain's wife. We now encountered such violent weather for four days that it was a miracle the vessel escaped. An enormous iceberg appeared in front of us, from which only a series of tacks saved us. During our sojourn at that little island three of my men made a two days' excursion, which enabled them to explore the seas between Adelaide and Terre Loubet. To the south of Marguerite Bay we were continually fighting our way through ice and icebergs, but we managed to take soundings of the sea bottom round 120 miles of unknown coast. After two attempts to find our way across the ice to Alexander Land we decided to abandon the project till the following summer.

Despite our efforts to do so we were unable to winter here. Even if we had decided to do so it would have been disastrous to our observations, and the drift ice would have carried us far from the land. It is impossible to convey any impression of the icebergs and the drift ice in this region. We were obliged to return to Petermann Island, where we were able, with our superior equipment, to confirm and amplify the observations made by the "Français" and other expeditions. This summer campaign, despite some bad weather, provided us with sufficient atmospheric clarity to take numerous photographs and make observations. The battle with the ice was severe and continuous, but the vessel behaved admirably.

Our winter station was organized as comfortably as possible. Numerous observations were taken with the electric light, and during a three days' tour I found that the movable house of the "Français" made a more comfortable observatory. During the autumn we made numerous excursions. We saw no sun for five days; the wind blew strongly from the northeast, and the snow fell heavily. The ice floes were continually shifting. Many icebergs passed. Despite all precautions our barrier was frequently broken. The ship was often in danger, and her rudder was smashed; we constructed a new one by cutting up a spar.

This painful winter had a serious effect upon the health of the party. Several suffered from scurvy, and one from myocarditis. It was only seal's flesh which kept us alive.

An expedition to cross Graham's Land was prepared with great care. I intended to lead it myself, but I was disabled by scurvy. Gourdon took my place, setting out with six companions. They brought back some interesting observations, but without being able to scale the insurmountable barrier of granite and ice. Other excursions were also made. After considerable trouble, toward the end of November we were able to get the ship free. We returned to Deception Island, where we found some whalers who had been held up by ice and bad weather. Here we were heartily welcomed by M. Anderson and his wife on the Chilean steamer "Gobernador Bories." With great generosity they helped us by all means at their disposal and supplied us with one hundred tons of coal by order of the Magellan Whalers Society. As our vessel was making two tons of water an hour, the diver who had attempted to float the steamer "Telefon," stranded the year before, examined our keel. He could do no more than confirm the gravity of the damage to the bow and some minor damages. We rapidly installed our scientific apparatus on shore. Our naturalist and geologist were able to perform some good work. From Deception Island I wanted to make for Joinville Land to seek for fossils, but the ice very quickly compelled me to change my plan. We did not wish to endanger our journey southward or to suffer the fate which befell the "Antarctic" in the same latitude. After a brief struggle we were beaten back to Bridgeman Island, where we landed, then to Admiralty Bay and the south coast of the Shetlands, where we did some good work.

Thence we set out to the south, the weather all along being bad and misty, and the ice and icebergs abundant. Nevertheless, we were able to go beyond all the latitudes attained to the southwest of Alexander Land and to complete the chart.

We then discovered a series of new lands to the south and west of Alexander Land, in an unexpected place, thus solving an important problem. The deplorable ice belt barred our nearer approach; in one hour we got no farther than ten yards! We continued our route by following the ice barrier until we reached Peter I. Island, which has not been seen since Bellingshausen discovered it. There we were overwhelmed by a tempest and thick mist, during which we had to steer carefully among the icebergs. They were so numerous that I estimated we saw more than 5,000 of them in less than a week. We had to drift, without steam, all the time, through a fog so dense that we could not see farther than twenty yards ahead. Despite this and the strong gusts of wind we reached the 126th degree longitude west, having sailed from the place where the "Belgica" set out, between 69 degrees and 71 degrees latitude, that is to say, well to the south of both Cook and Bellingshausen. Our stock of coal being exhausted, the health of several of the party became alarming. We had to turn our faces northward; for a long time the icebergs had been innumerable, but they gradually diminished, and finally we saw the last. The crossing of the Antarctic to Cape Pillar was extremely rapid, thanks to an uninterrupted series of southwesterly and north-northwesterly winds, but the sea was terrific. In ten days we arrived at the entrance of the Magellan Straits, where we encountered severe weather.

We experienced several anxious hours round the coast, but the magnificent qualities of the vessel and her fine machinery, aided by sails, enabled us to make good use of the wind and to anchor for some hours in Tuesday Bay. The men's health and the necessity for condensing water for the boilers determined me to spend four days in the straits. Owing to the unfavorabe situation in Tuesday Bay we moved on to Puerto Gallante, where we were able to procure fresh meat and vegetables. We anchored at Punta Arenas, where we were heartily received after fourteen months absence. During the second summer campaign as well as the first, numerous soundings and draggings had been carried out. Whether among the ice or upon the open sea the vessel behaved excellently, and we had not a single breakdown of the machines. The ship must have been remarkably solid to stand it all. Her equipment was perfect. As for the staff, the scientific results of the mission are due to their noble and incessant labor, while the scientific programme was scrupulously carried out.—London Standard.

With the ordinary method for examining a transparent body under stress by means of polarized light, the body is placed between crossed Nicol prisms. Under these conditions the optical effect observed depends on the particular angle at which the specimen, or any part of it, is placed, and if the stresses are radial in direction, as with a short cylinder or circular disk of glass which has been suddenly cooled, a black cross is observed with its pairs of arms respectively parallel to the planes of polarization of polarizer and analyzer, the light being a maximum for directions making 45 deg. with these arms. In a paper read before the British Association for the Advancement of Science at its Winnipeg meeting, S. P. Thompson and E. G. Coker show that these disadvantages are avoided by substituting circularly polarizing apparatus for both analyzer and polarizer. For this purpose use is made of two thin plates of mica (or of quartz cut parallel to the axis of crystallization) which gives as nearly as possible a retardation of one-quarter wave-length for yellow light between their ordinary and extraordinary rays. Ordinary quarter-wave plates differ considerably among themselves, and it is important that the pair chosen should be alike in optical property. One must be large enough to cover the whole field of view, this being placed between the polarizer and the object—preferably attached to the polarizer—and set with its axis at 45 deg. to the plane of polarization of the polarizer. The smaller quarter-wave plate is placed between object and analyzer—best attached to the latter—so as to rotate with it, its axis being exactly at 45 deg. to the plane of polarization of the analyzer. If this plate receives a beam of circularly polarized light, it transmutes that beam into plane-polarized light, which is either cut off or transmitted by the analyzer, according to whether its own axis is at 45 deg. to the left or to the right, that is, according as the cheirality of the analyzing combination of quarter-wave plate and nicol is opposed to or concordant with the cheirality of the polarizing combination. With this arrangement the black cross entirely disappears, and, with the exception of certain slight changes of tint, the optical appearance of any polarizing object placed in the apparatus remains invariable at whatever angle that object is placed in the field. As a material more compressible than glass, and hence not so readily fractured, Thompson and Coker employ a particular kind of xylonite; sheets 3—4 millimeters in thickness being practically transparent, even 10 millimeters thickness may be used.

A consideration of the mechanical principles involved in valve construction and the duty required lead to the conclusion, says a contemporary, that electrically operated stop-valves offer many advantages as compared with the hand-operated type. They can be operated from any point, often permit a simpler laying out of piping, and, in time of accident, make it possible to shut off a valve that might otherwise be inaccessible on account of fire, escape of steam, etc. The stopping and starting of large units upon short notice is expedited by motor-driven valves for the large exhaust piping, and when installed between the boilers and steam header, or the header and the engine, and between sections of the header, they enable any break in the piping to be isolated at once, or any other trouble checked by closing switches which may be situated a safe distance away from the piping.

THE MECHANISM OF PROGRESS.

A THEORY OF INVENTIVENESS.

BY PROF. R. S. WOODWORTH.

PROGRESS depends first of all on human inventiveness—so much will probably be allowed. Under the head of inventions should be included, not only mechanical devices, but works of art and government, business enterprises and changes in custom, so far as any of these demand originality in their producers. Science and all increase in knowledge should also be included, since the process of discovery differs but little from the process of invention. In both the essential mental act seems to be a bringing together of things that are found apart, or a pulling apart of what occurs together. In fact, both of these processes, the combining or associating, and the analytic or discriminating, go on together, since we see something new in a thing when we are reminded by it of something else and different. There is a suggestion of the accidental in all invention, since it depends on "happening to notice something," or "happening to be reminded of something." You can not be sure that a person will make a discovery, even when you supply him with the elements which would combine to produce it. Oftentimes, in reading the history of scientific progress, one is surprised that a certain discovery was not made by some man who had apparently everything before him to lead to it. Invention is of the nature of a spontaneous variation, and this accidental character is very important in understanding the mechanism of progress.

On the other hand, since one cannot be reminded of things entirely unknown, invention depends on previously acquired knowledge, and the inventiveness of an individual must take a direction prepared for him by the social group among which he lives. A large share of the inventiveness of the Australian natives seems to be directed into the channels of magic and ceremony. The finished product of one mind's inventiveness becomes raw material for another, and invention of all sorts is distinctly a co-operative enterprise.

Invention is said to be mothered by necessity; and the proverb is no doubt true in the main, though curiosity and experimentation belong among the play instincts. But, in any case, the necessity must not be too dire, for some degree of leisure is demanded if anything novel is to be thought of, and rapid progress is only possible when individuals can be allowed to accumulate the special knowledge which may serve as the raw material for their inventive activity. Divisions of labor, guilds, universities, legislatures, investigating commissions, permanent research bureaus—each of which is, genetically, a series of inventions—are dependent for their existence on a certain degree of leisure, while they in turn provide more leisure and opportunity for further advance. They are inventions which accelerate the progress of invention. There are thus many factors besides the intellectual endowment of a generation which go to determine the progress which it shall make. The spur of necessity, the opportunity afforded by leisure, the existing stock of knowledge and inventions and the factor of apparent accident or luck have all to be considered.

A still further factor is the size of the group, which is deserving of renewed attention. Not only does a large group afford more opportunity for division of labor and special institutions for research, but the biological consideration already mentioned should be emphasized. The contributions to progress of the average man are small, the inventions of moment arising in the brains of a small fraction of the group. A large group provides a greater number of inventive minds, and it is rather the absolute number of such than their proportion to the whole population that determines the progress of invention within a group. The "group" needs to be redefined from the point of view of invention. If knowledge and inventions pass back and forth between two nations or races, the inventive minds of both are brought into co-operation, and the group is by so much enlarged. From the point of view of progress, however, the question is not simply how many inventive minds are brought into co-operation, but how free and rapid the communication is between them. At the present time, a discovery originating anywhere in Europe or its colonies is quickly known by specialists in all parts, and may promptly fructify the mind of a distant investigator, leading to a fresh advance. The invention of printing and of rapid means of communication must be credited with a large share of the rapid progress which has been made by the last few generations. Much also must be credited to the invention of steam power, which has vastly multiplied the size of the European group, in an economic sense, and set free many minds of ability for productive thinking. The very idea of the advancement of science and invention as an end to be striven for is to be classed as an invention, and a rather recent one; and it, too, is an accelerator.

Such considerations provide at least a partial explanation of the different rates of progress in different generations, and among different races. Whether they explain everything could perhaps only be determined by a drastic experiment, which it will do no harm to imagine, though the question will never be settled in this convincing way.

Let two or more habitats, isolated from each other and from the rest of the world, and as nearly as possible alike, be chosen, and peopled by two equal groups of children, selected from some highly civilized nation, and so selected as to represent fairly the distribution of mental and physical traits among that nation. For every individual in the first group, let there be a practically identical individual in the second. Let these groups of children be introduced into their new homes in infancy, and, by some quasi-miraculous means, let them be all preserved to maturity, and then let them, and their descendants, be left entirely to their own devices, without fire, or a language, or other modern improvements. To watch such a spectacle from afar would be thrilling, if not too pitiful. We can readily grant that the infant communities would begin at the very zero of civilization, and that their progress, for many generations, would seem excessively slow. But the real point of the experiment is to inquire whether these two equal groups, alike in numbers, in heredity and in environment, would remain alike, and progress at equal rates. Probably they would not. We must allow for a large element of chance in the mating of males and females within each group, and consequently for changes and inequalities in the distribution and correlation of traits—changes which need not alter the average of either group.

We must also allow for spontaneous variation in the offspring, another accidental factor by virtue of which a really inventive and effective individual, or conjunction of such, would almost certainly arise in one group earlier than in the other, and give the advance of one group an impetus which might be felt through many generations, and carry this group far ahead of the other. And we must allow also for the accidental factor in invention. Even though the genius of one group was paired by an equal genius in the other, it is improbable that both would invent the same things. One might invent a hunting implement, and the other a fishing implement; and by this accident the direction of development might be settled for each group. If we closed the experiment after a thousand generations, we should probably find two peoples of different languages, different customs, and cultures divergent in many respects. The supposed result may be taken as an assertion of the importance of accident in determining the destiny of peoples. Obscure causes are no doubt at work beneath the accidents, but we cannot trace them, nor reasonably state them in terms of racial superiority and inferiority.

It would seem that size of groups, and accidental factors, exert so much influence on the rate of advance in civilization that differences of culture could possibly be explained without supposing the mental endowments of the races to differ. Whether the existing races of men do or do not differ in such a trait as inventiveness is another and more difficult problem, the settlement of which must be left to time and educational experiments. The experiments must be continued for several generations, in order to equate social traditions. Regarding the negroes of the south, I am informed by a gentleman who has spent twenty years in educating them that a distinct advance is perceptible during this period, especially among the children of educated parents. These have more educational ambition, enter school earlier and have less to unlearn. The educational experiment, as far as it has gone, thus shows that much time will be needed before a clear result is reached.—Abstracted from a paper read before the American Association for the Advancement of Science.

AN ELECTRO-MAGNETIC SOUNDING APPARATUS.

By the Berlin Correspondent of the SCIENTIFIC AMERICAN.

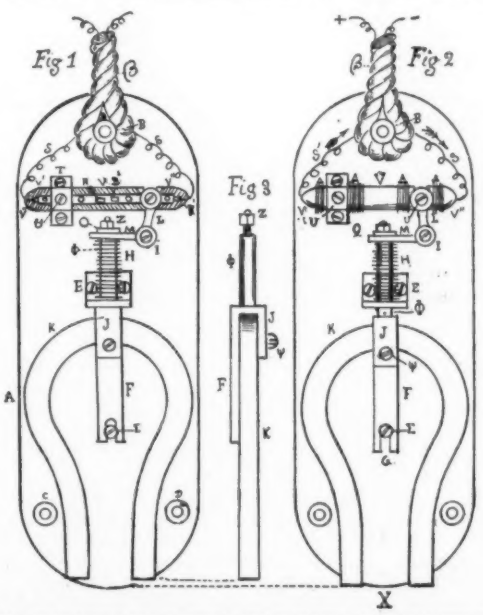
AFTER the loss of the submarine "Lutin," in 1906, Mr. Augustin Coret of Neuilly, near Paris, conceived the plan of an electro-magnetic sounding device to locate a lost automobile torpedo.

The inventor has now improved his original scheme by replacing the electro-magnet by a permanent horseshoe magnet.

The electro-magnetic sounding device consists of two copper plates *AA*, united by ivory pegs *BCD*. To one of these pegs is fixed by means of two screws a square *E*, into the hole of which penetrates the round portion of the guide of a magnet *K*. The plane portion *F* of the latter carries an angle 5, in which the magnet is fixed by a screw ψ, while its end is attached to the plate *A* by a screw Σ passing through a slot *G*.

The upper end of the guide is connected with the arm *M* of a lever *i*, through which it passes. A nut *Z* and a ring *O* cause this lever to take part in any motion of the guide. The other arm *L* carries a round head *P*, in which is fixed by a screw *U* an ivory or ebony rod *OO*. To this ivory rod is screwed one of the contacts *R* of the wire 3, supplying current through a cable fixed to the apparatus from a battery installed on board a ship or boat.

The support *T*, fixed by two screws to the plate *A*, carries, by means of another screw *U*, another ivory rod *OO*, into which is screwed the other electrical contact *R'*. The conducting wire *S'*, connected to *R'*, communicates with the cable and the other terminal of the battery. The ivory rods are covered with caoutchouc sleeves *VV'V'*, to insulate them against sea water. These sleeves are kept on the rods by windings of copper wires. A spiral spring *H*, surrounding the round portion of the magnet guide, and pressing against the square *E* and the arm *M* of the lever *L*, prevents the electric contacts from touching one another as long as the sounding apparatus is kept away from any iron or steel masses.



AN ELECTRO-MAGNETIC SOUNDING APPARATUS.

In order to locate a submarine or torpedo at the bottom of the sea, the sounding device should be taken to the spot. As soon as its magnet approaches a piece of the iron or steel of the hull it will be attracted, and owing to the effects of the spiral spring, the two contacts will touch each other so that the electric current, by actuating a bell installed on board a ship or boat, indicates that the submarine or torpedo is really at that point. In case of a negative result, a sounding should be made at another spot, and the diver should not start his work before the bell has signaled the presence of the submarine or torpedo.

Should the sounding device come into contact with the bottom of the sea or else with a stone or other solid object (not of iron or steel) the impact will cause the contacts to touch each other, thus actuating the bell, but only during one or two seconds, as the force of the spring immediately separates the contacts. Whenever the magnet is attracted by iron or steel, the bell is rung uninterruptedly.

MODERN STEREOTYPY.*

THE MECHANICS OF THE NEWSPAPER.

BY HENRY A. WISE WOOD.

PRINTING began with the making of handcut blocks, which were used to stamp their similitude upon other surfaces. Later, blocks called type, bearing each a single character, were made, and these, when combined one with another, produced words which, when gathered into sentences and paragraphs, became the page. The great impetus given the typographic art by the introduction of "movable types" was due to the ease and economy with which text could be prepared for the press, and after printing the type page resolved again into its component characters, which thereupon were fit and ready for further use.

The work of cutting characters being slow and costly, recourse was soon had to casting them, of an alloy of lead, antimony, and tin from molds, now called matrices. These were made of plaster from types or dies which had been cut by hand; and later of copper from harder dies which, upon being driven into it, left their impress. Until recently the driven matrix was exclusively used; but nowadays the manufacturers of type cut their matrices by means of a power-driven engraving device, the controlling lever of which is guided by hand along the edges of a large template, or raised representation of the particular character to be cut. Thus by means of the Benton-Waldo machine unskilled men, working with great rapidity, can produce the most intricate matrices at little cost. When matrices are required to be made in large quantities, as for use with the type-making and composing machines of the modern printing office, they are still driven, the dies, or "punches" employed, being engraved by the Benton-Waldo method. The matrices of extremely large type-sizes which are now upon the market, are usually neither punched nor cut, but are electrolytically-deposited copper impressions of existing types.

For many centuries the setting of type was a manual operation. It required a high degree of special knowledge and great dexterity. With the setting, or "composition," of a page the type-setter's work did not end; when the page was no longer required he had also to "distribute" the type it contained. The putting of matter into type involved the necessity of taking it out again. Such a dual process was entirely comfortable to the printer until, and long after, the newspaper came into being. But when the value of celerity in the printing of news began to be understood, the slowness of "the man at the case," became irksome, and a mechanical substitute for his eyes and hands was sought. This brought into being the crude type-setting devices of the third quarter of the last century. These, like the man, had to distribute as well as to compose, and each function was given a mechanism of its own.

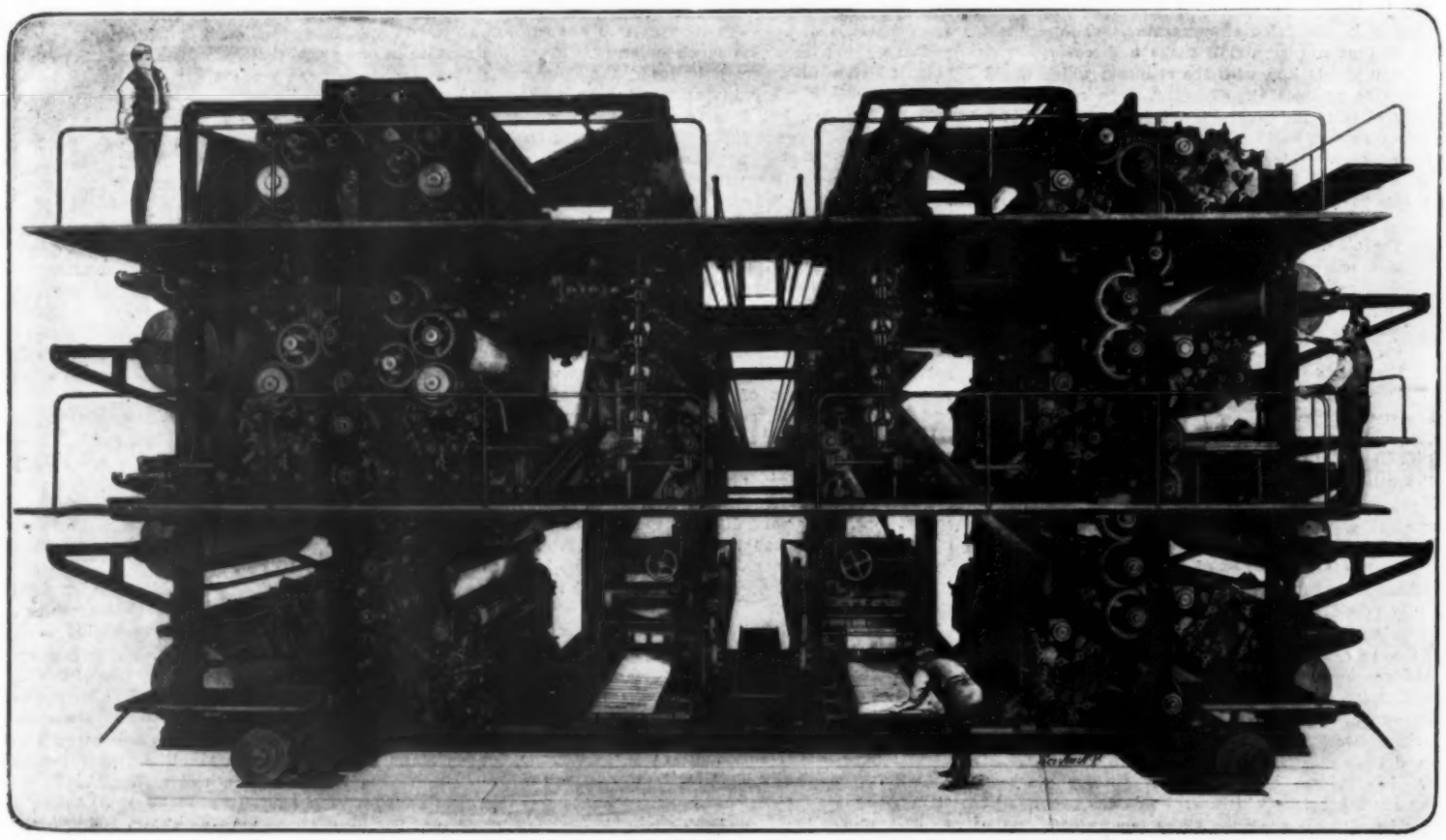
Meanwhile the growth of the newspaper in telegraphic matter and general bulk was pushing it on to demand still more rapid and ample appliances; and these so far as the composing room was concerned were at last supplied by Mergenthaler's matrix-setting-and-type-line-casting machine, called the Linotype (line of type). This device worked upon a new principle. Instead of seeking to set the types, and after their use to distribute them among their respective receptacles in order that they might again be automatically composed, it composed the matrices of type, and from these cast, as a single piece, a line of characters. Mergenthaler's matrix was of brass, flat and rectangular, having a V-shaped notch cut deep into one, its upper, end, the edges of which were lined with small hook-like protrusions. These protrusions were arranged to act like the convolutions of a flat lock-key: because of them a matrix could drop from the V-shaped ward bar from which it hung during its automatic distribution after use only into its own reservoir, or channel, of the matrix magazine. The magazine and matrix distributing apparatus occupied the upper portion of Mergenthaler's machine and to it, after each had been once used, the matrices were automatically returned. The convolutions of the matrices of each character were alike; but those of no two characters were the same.

From the channel-like reservoirs of the magazine the matrices were released in the order in which they were wanted, by the manipulation of finger keys; and upon coming from the magazine were assembled side by side with their intaglio characters in line. A wedge-like piece was inserted between each pair of words to wedge the line out to its full width should it be short, a function spoken of in typography as "justifying." The assembled matrices and wedges were thereupon automatically transported to a casting mechanism, where their character-casting surfaces were pressed against the mouth of a slot or mold which was as long as the width of the column of the newspaper for which the line was to be cast, and of breadth suitable to the size of the type face required. In depth the mold was type-high. Against the opposite opening of the mold was placed the nozzle of a pump, by which, at the proper moment, the mold was filled with type metal and a bar cast having upon one edge the line of type. The mold was then automatically moved clear of matrices and of pump, and the bottom of the cast smoothed by a knife. Then the cast, or "slug," having been ejected between knives to give it accurate thickness, was ready for use. Meanwhile the matrices were lifted to a position abreast the top of the line of reservoirs from which they had come; whence, suspended each by its particular convolutions from the wards of the V-shaped bar along which they slid, they were pushed over the mouths of the channels, and each character dropped where its retaining ward ended. The wedges or "space-bands" were left behind when the matrices were "elevated," and returned to their starting point.

Thus, by the mere acts of playing his keys and touching a handle upon the assemblage of a line of matrices, an operator was enabled to make composed and justified lines of new type at a then unheard-of rate of speed. Moreover, the "type" he had set needed not to be distributed for re-use; the line had only to be tossed into the melting pot of the machine to be born again as new matter. Where other mechanical compositors had required three men for their use, one to set, another to justify, and a third to distribute their work, the Linotype needed but one, and could be worked with such ease and rapidity that it went instantly into general use.

Upon the heels of the success of the Linotype came another device, the Monotype, which, although not of so great value to the newspaper publisher, was gladly received by the printer of books and commercial work. The Monotype consisted of two independent mechanisms, the one a keyboard by means of which the operator was enabled rapidly to perforate a paper ribbon

*Read before the Franklin Institute.



THE LARGEST PRESS IN THE WORLD—THE DOUBLE SEXTUPLE PRESS FOR NEWSPAPER WORK.

Two complete printing mechanisms each fed from three rolls of paper. Twelve plate-carrying cylinders each carrying eight plates. Press is 35 feet long, 17 feet high, and weighs 225,000 pounds. Fifty thousand parts. It will print 150,000 eight-page papers per hour, and deliver them folded and counted.

with holes which represent characters, and the other a type-casting mechanism to which the perforated tape thereafter was fed. The latter device comprised a movable frame in which the matrices of 225 characters were fastened, a type mold, automatically adjustable to suit the various widths of the characters of the alphabet, with which a metal pump was connected, and pneumatic mechanisms for controlling the position of the matrix-carrying frame, and the width of the type mold. To these was added a general mechanical organization which enabled the perforations of the ribbon, by means of air, as it was drawn through the machine to properly place the matrix frame and set the mold for each character needed, while the pump and co-operating parts acted to cast the character and place it in its correct position in a tray, or "galley," at the rate of 150 characters a minute.

Of all the type-setting machines, properly so called, which preceded the Linotype but one has survived—the Thorn-Simplex-Unitype machine. In this foundry type are contained in slot-like reservoirs cut in the periphery of a drum. About the bottom of this drum, which stands on end, rotates a flat disk, and out upon this the type are thrust when released by the keys, and by it are carried in the order of their release into a mechanism which picks them up, puts them on their feet, and assembles them into a line. They are then taken in lengths of a column's width and, after being quickly justified by hand, are ready for use. A clever device of this machine is the means by which it is enabled to take a whole galley of type, and properly distribute it among its reservoirs. This is accomplished by providing the type-body of each character with an arrangement of "nicks" which is possessed by the body of no other characters. At the head of each slot-like reservoir is a particular arrangement of wards, like those of a lock. The wards of a reservoir will permit to enter it only the character whose body has nicks to suit. The lines of type which are to be distributed are automatically taken from their galley and inserted, a line at a time, into slots in another drum. This surmounts the reservoir drum already referred to, their axes and the alignment of their slots being common to both. The upper drum rotates with a step-by-step motion, and at every stoppage its slots coincide with those of the lower drum. Thus it will be seen that as soon as a character carried by the distributing drum reaches a position above its own reservoir, it will drop into it, but that no other character can do so. The Unitype machine, being less costly to purchase and more economical to run than Linotype or Monotype, is in very wide use among the smaller newspapers and printers of books and magazines.

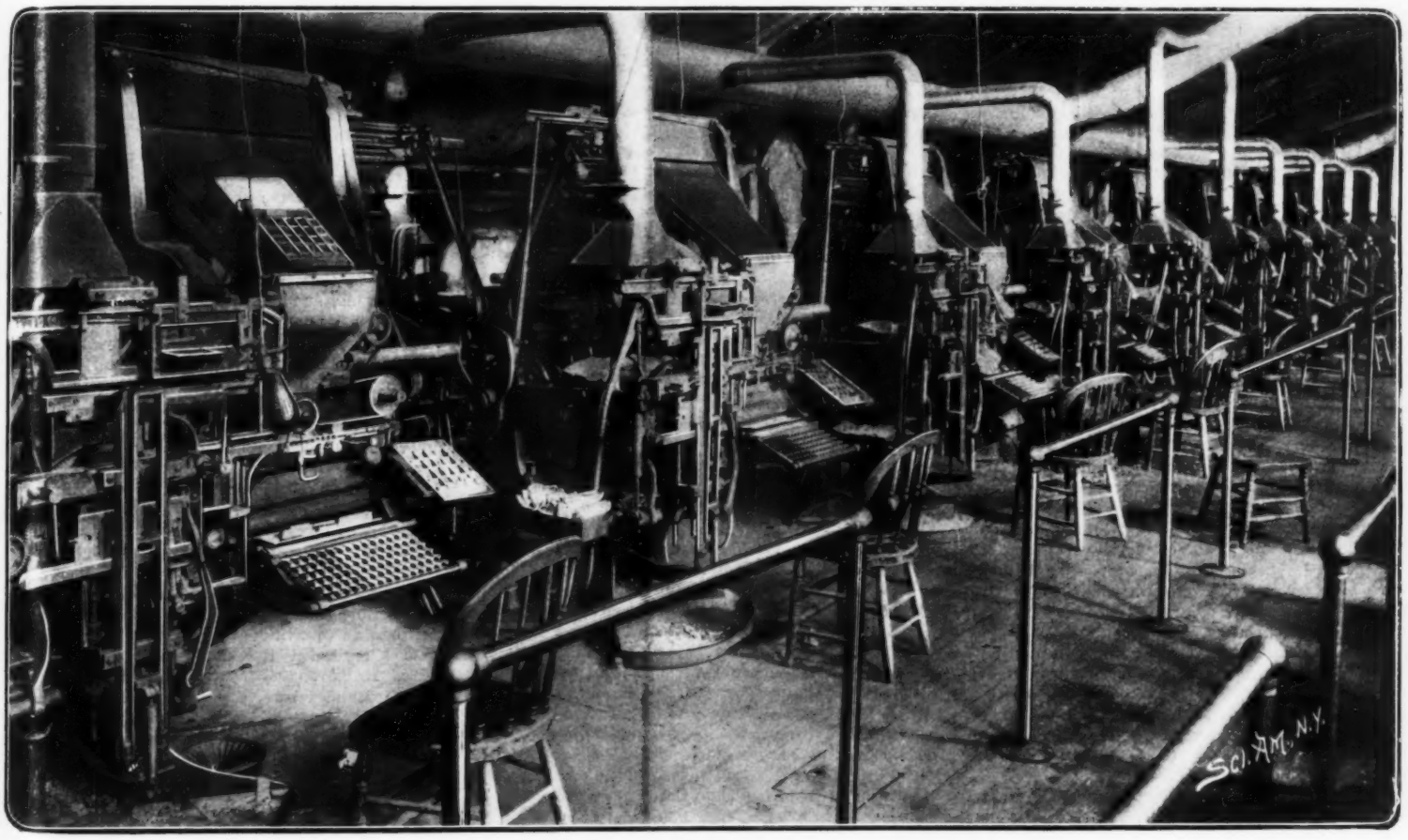
In these few words I have sought hastily to carry the art of type-setting through its various stages of progress, and to describe the mechanisms by which it is practised to-day. Where an expert compositor formerly could set by hand but 750 "ems"* an hour, he has been known with a modern machine to set from 3,000 to 12,000 ems. Such large daily papers as the New York Herald and the New York World use from 60 to 70 Linotype machines each (the New York Sun uses Monotypes). Without such a machine it would be physically impossible to issue newspapers of this class, in so far as their bulk and the celerity of their publication is concerned. So much has the mechanician done for the setting of type.

Coincident with the introduction of movable types one first hears of the printing press. This instrument is said to have come of humble origin; to have been in fact but a development of the cheese or cider press common in mediæval times. It first consisted of two plates between which the inked type, covered with a sheet of paper, was introduced and by which it was pressed. The necessary squeeze was applied by means of a hand-turned screw, set in a surrounding frame, which bore upon the upper plate. Next came an improved form of screw-operating mechanism. Next, the lower plate was made to slide out to receive the type "form," as it is now called. And later a frame, covered with fabric to which the sheet was secured, was made to hinge down upon the type before the table upon which the type rested should be slid beneath the upper plate. This table is now called the "bed," and the sheet-pressing plate the "platen," of a press. In those days the ink was applied by means of hair-stuffed leathern balls. These, dabbed with ink, were patted together until their ink film was suitably evened out or "distributed," and were then carefully pressed upon the type. With such a press about 200 sheets of small size, printed upon but one side, could be done in an hour. At its next step the press became of iron, and was adapted to print larger sheets. Then a genius conceived the idea of replacing the flat, sheet-pressing platen, by a rotating cylinder upon the surface of which the sheet was held by bands of tape. Beneath this cylinder the type form was pushed, and thus the cylinder printing press was born. Next were applied ink-charged rollers made of glue and molasses which, as the type was pushed toward the cylinder, served to ink it. Better means for propelling the type-bearing table or bed were soon forthcoming, as well as for causing the cylinder to turn more accurately, and with greater certainty to take on and give off the sheet. Power other than that of the hand was applied, and it became possible to print upon one side of a sheet at the rate of a thousand "impressions" an hour.

Meanwhile the flat or "platen press" as it is called shared in the general advancement of the engineering arts. It became a self-acting machine; of itself took its sheet from the hand of the printer and drew it into position to be printed, and impressed it upon the type, which it had previously inked. Thereafter it gently laid the sheet upon a table, a thousand such sheets to the hour. Having attained to this degree of development the growth of the platen species of printing press ceased forthwith and, except in connection with the smaller sizes of commercial work and a few obscure branches of the printing industry, it is no longer a factor.

As an increasing speed of production is ever of the essence of industrial progress, the mechanical species which survive are necessarily those which lend themselves to celerity. Of such a species was the cylinder printing press. With the betterment of materials and of motion-producing mechanisms, the attainable speed of its reciprocating type bed and its sheet-bearing cylinder soon enabled it to outrun the older and more cumbrous flat press; and thus it came to assume the burdens of news printing. The single-cylinder press, printing upon one side of a sheet, was soon followed by a machine having two sheet-bearing cylinders, and a double-length bed upon which forms of type for printing the back as well as the front of a sheet were borne. By an ingenious arrangement of endless tapes the sheet, having been printed upon one side by one cylinder, was transferred to another cylinder and by it printed upon its other side. Such a press was said to "perfect" the sheet, and so came to assume the name of "sheet perfecter." Other double-cylindered presses, also, were used, which were adapted to print upon but one side of the sheet. Such a machine carried upon its bed a single form of type to which each cylinder in turn presented a sheet; the one cylinder upon the forward stroke and the other upon the backward stroke of the bed.

Fifteen hundred papers an hour were not, however, long going to satisfy a public rapidly growing in its appetite for news; so another step was taken, this time by Applegath, for the London Times. By setting a cylinder upon its end, its axis in vertical position, and fastening into it the metal column rules of the paper, Applegath was enabled to lay the columns of type between these rules and so clamp them to the column-wide facets of his cylinder as to cause the type to withstand the centrifugal force of a quite respectable velocity of rotation. About this type-bearing cylinder were set parallel sheet-bearing cylinders, to and from which hand-fed sheets were conveyed by rather complicated systems of tapes. In this way the Times for many years was printed. Hoe in this coun-



BATTERY OF FIFTY-SEVEN LINOTYPE MACHINES.

Average product, 4,000 letters the width of the letter "m" per hour. Each machine spaces or justifies the line and delivers a cast slug.

* The "em" represents the square of the size of the type used, and is derived from the letter M, which is as broad as it is long. It is the unit by which composition is measured. If a column is 12 "ems" wide and 50 lines long, it is said to contain 600 "ems."

MODERN STEREOTYPY.

try conceived a better arrangement. By the use of wedge-shaped column rules he was enabled so firmly to hold the columns of type in place as to enable him to set his cylinders in a horizontal position. Hoe presses having four, six, eight, and even ten sheet-bearing cylinders, which ran in contact with a central type-bearing cylinder, came into general use. Having a "speed" of two thousand turns of the type cylinder an hour such a press, with ten sheet-bearing cylinders, was capable of turning off twenty thousand sheets. These, being printed upon but one side, had of course to be put through the press again, the type pages meanwhile having been changed. Hoe's next step was to place in a machine two type-bearing cylinders so that both sides of a news sheet might be printed at a single operation.

But even ten or twenty thousand newspapers an hour failed to satisfy the growing public need. The presses of the day were already working at top speed. Type-setting was so slow and costly that forms could not be set for more than one press; so an establishment was limited to the use of a single machine. Something had to be done. For some time there had been known and used the process of stereotyping, which was that of producing replicas of a form of type, in type metal. To practise stereotyping a type form was stamped into a moist clay surface, where it left its impression. The clay was baked, then put into a receptacle and type metal poured upon it. When the cast had cooled, the clay was broken from its surface, its edges were trimmed with a tool, and its back smoothed with a plane. Then it was ready for press. By repeating the processes of molding and casting it was possible to continue indefinitely to reproduce a type form. But the resulting stereotypes were flat, and for the rotary news press it was desirable if higher speed were to be obtained that printing forms should conform to the curve of its cylinder.

In this hour of the newspaper's need someone, it is not certain who, conceived the idea of substituting for the clay for stereotyping a sheet of papier maché. This was composed of several thicknesses of soft paper moistened with paste and covered with a skin of tissue. It was laid upon the type and beaten in with a brush. Type and paper were then covered with a dry blanket of felt and thrust into an oven-like press till the matrix was dry. Such a matrix, being flexible, could be conformed to the interior of a curved casting receptacle and, being tough, could be stripped from a cast and used again. This method of stereotyping originated abroad, and was brought to this country by Traske who first put it to work upon the New York Herald and the New York Sun. Thus, for the first time, the newspaper was enabled to make innumerable curved replicas of its type forms, and indefinitely to multiply the number of its printing machines. It should be noted in passing that with the advent of the curved stereotyped printing plate the larger newspapers ceased for good to use type for the purpose of printing.

The substitution of curved stereotyped printing plates for type gave to the newspaper two new advantages. Many presses could be used; and these could be run at higher speeds than were possible where printing surfaces were made up of individual types which were held to a cylinder merely by wedges. Bullock, of Pittsburg, was the first to offer a press which properly utilized these advantages. His machine was not only adapted to use curved stereotypes at a high rate of speed, but to it he had attached a device for severing sheets from a roll of paper, thereby feeding his press automatically; and another device for rapidly laying the sheets when printed neatly in pile. His press, thus being automatically fed and delivered and adapted to print from curved plates upon both sides of a sheet, quickly came into general use. Hand-fed machines for folding newspapers were already in vogue, so it was but a short step to the attachment of such a folding machine to the press itself.

But progress was still insistently at work. The annoyance of carrying separate sheets through a rapidly-running machine must be dispensed with. This was soon accomplished, and the paper was drawn from the roll into the press, and printed while still in "web" form upon both its sides. Then it was cut into sheets and folded. Thus there resulted the web-printing, as distinct from the sheet-printing, machine.

Further improvements now follow one another in rapid succession. The slow, intricate, and uncertain chopping-blade folder at first employed was replaced by a rotary device which, working with simplicity and accuracy at a much higher velocity, greatly increased the productivity of the press. The products of two presses were next run into a single folder which thereupon delivered a folded newspaper of double the usual number of pages. These two innovations were first put into practice by Andrew Campbell* of New York city. The columns of the print, which theretofore had run across the web, were next turned about and run with it. Thus the center margin of the newspaper along which it is folded became the center line of the web. As a curved stereotyped plate occupies but half the circumference of the cylinder of a newspaper press, two were required to complete the circle. As each printing cylinder bore four such plates and there were two such cylinders it was possible at each revolution to print an eight-paged paper. By cutting the sheet from the web between the forward and after pages and laying the first half upon the last, an easily handled eight-paged paper became possible. Such a paper had neither to be cut by hand nor turned inside out in order that its pages might be read by the holder in sequence. This operation was called "collecting." There were occasions when the forward and following plates were alike; then the sheet-collecting mechanism was disconnected, and the papers delivered had but half the number of pages. In this way four-paged papers were run. Such a press was able to deliver twice as many papers having four pages as eight. The products of two printing machines, when run together into a collecting mechanism and folder, resulted in sixteen-paged newspapers. But with the collector thrown out of operation, twice as many eight-paged papers could be obtained. With three presses the respective products were twenty-four paged, if collected; twelve, if uncollected; with four presses, thirty-two, and sixteen. Meanwhile it had become possible to combine the full-width web of one press with a half-width web, one page in width, brought from another. Thus, such a product if not collected produced a six-paged paper or, if collected, a paper of twelve pages. In this manner it became possible to print at will, upon a machine having four printing-couples, newspapers with four, six, eight, ten, twelve, fourteen, sixteen, twenty, twenty-four, twenty-eight, or thirty-two pages.

Meanwhile the practice of cutting sheets from the web before they were folded had given way to a more certain and rapid method. A new form of folding device was introduced, which comprised a V-shaped frame of iron down over which the printed web was drawn by two milled rolls running toward each other at its lowermost point. The web coming full width over this device, was so shaped or formed in the course of its travel downwardly over its face and about its sides, as to enter the rolls beneath its "nose" as a folded web. Thus it became possible to give the sheet while "on the run" its first, its longitudinal fold, and to do this before it should be severed from the web. Beneath this device, or "former," as it is called, was placed a pair of cylinders which co-operated to give the already once-folded sheet its second, or transverse, fold and thereafter to sever it from the web. The act of cutting was accomplished by pressing a sharp, serrated blade carried by one cylinder into a slotted rubber bar carried by the other. The principle of cutting demanded that the sheet be held taut over the cutting slot while the saw-toothed blade burst through it. This was accomplished by placing at each side of the knife spring-supported wooden bars which, pressing the paper against the rubber at each side of the blade, held it taut at the moment of cutting. One of the cutting cylinders bore pins which, by impaling the leading end of the once-folded web, enabled it to carry the paper part way around until the instant arrived at which it was cut from the web and became a "sheet." Then, as the pins released its forward end, it was struck across its middle by a suddenly-protruded folding blade, carried within the cylinder, and driven downwardly between a pair of co-operating rollers by which a second or transverse fold was given it. The twice-folded paper was then shot into a rotating frame of S-shaped arms, called a "fly," which laid it upon a slowly-moving apron of endless bands from which, when papers enough had gathered, it was removed by hand. Working in conjunction with the fly was a device which slightly threw out of position every fiftieth paper; so the necessity of hand counting, except for smaller quantities, was dispensed with. It should be added that the cylinder which was opposed to the sheet-bearing cylinder described, was so fitted with pins that it could also perform the function of collecting, and thus papers of double the number of pages be produced. This cylinder bore the serrated knife, while the sheet-bearing cylinder carried the rubber slot and folding blade described. When it was wished to collect the forward with the after product of the press, the pin mechanism carried by the knife cylinder picked from the other cylinder the first-coming sheet by its forward edge and, after making a revolution which gave the second sheet time to arrive, replaced the first sheet upon the first cylinder directly upon the second sheet. The collected product was thereafter folded, delivered, and counted as a single newspaper.

But two other features of the press under description—which is the newspress of the present day—remain to be mentioned. Some years ago it became the practice to construct presses four pages in width. This necessitated the employment of double-width webs. Its advantage lay in the fact that by means of two rounded bars, set at an angle of 45 degrees with respect to the direction of travel of the paper, it was possible after the web was printed and split to transfer part of it across the press and impose it upon its other part. Thus, the portion of the web printed at one side of a press could be transferred laterally, and associated with the portion printed at the other side of the machine, and both pass into a folder to emerge as a single product of a greater number of pages.

(To be continued.)

* Machines having Campbell's rotary folder were used by the Jersey City Evening Journal and the Cleveland Leader. In the last mentioned machine the webs of two presses were run into one folding mechanism and there assembled and folded as a single product. Campbell failed to patent his inventions, and thus lost them.

WIND STATISTICS FOR AERONAUTS.

THE appearance of a comprehensive analysis of the winds of Germany ("Die Winde in Deutschland," Braunschweig, 1910), prepared especially for the information of aeronauts by Dr. Richard Assmann, is significant of the fact that, in Germany at least, meteorology and aeronautics are advancing hand in hand. The author is director of the great aerological observatory at Lindenberg, and chairman of the scientific committee of a society of aeronauts at Berlin—the Motorluftschiff-Studiengesellschaft—under whose auspices and at whose expense the work has been published.

By means of tables, text, and wind roses there are presented statistics of the direction and force of the winds at forty-nine stations, well distributed over the empire. The stations were selected with due regard for the reliability and the length of their records. The average length of record was 20.8 years. In the original observations the force of the wind was estimated according to the Beaufort scale—not observed instrumentally—but the data have been reduced to equivalent values in meters per second. Comparatively few meteorological stations in Germany have anemometers, and the records made by this instrument are apt to be looked upon with less favor by German meteorologists than the estimates of experienced observers; the latter being based on the movements of smoke or low clouds, and therefore being freer from local influences than the readings of most anemometers.

This work, which in its scope and purpose is a novelty in scientific literature, is analogous to the sailing handbooks and pilot charts prepared for the benefit of the navigators of the ocean. It shows, for each station and for each season of the year, how often, on an average, the wind blows from each of eight points of the compass, and the average frequency of the several degrees of wind force, from a calm to a hurricane.

Besides its utility in indicating when and where aerial voyages may most safely be undertaken, and the probable drift of non-dirigible and low-powered aircraft, it will be especially valuable in pointing out the best locations for airship sheds. The operation of housing a huge airship, such as the "Zeppelin," in a high wind is so difficult and dangerous that places having a high percentage of stormy days in the year cannot, at least in the present stage of the progress of aeronautics, hope to become great "air ports" (if we may coin a word analogous to "seaport"). In general, places near the seaboard are unsuitable for this purpose, but Dr. Assmann's statistics show that quite a surprising number of inland stations are so stormy that aeronauts will do well to avoid them. It is interesting to discover that Friedrichshafen, where Count Zeppelin's great airship sheds are situated—one of them floating on Lake Constance—is by no means a favorable place for such structures, having a yearly average of 24.1 stormy days, compared with 2.2 days at Celle, 4 days at Berlin and Cassel, and less than 10 days at seven other stations.

A remarkable railway bridge is that known as the Assopus Viaduct, on a new line extending by way of Demirli to the Turkish frontier. This bridge, situated in a gorge which is 330 feet deep and about 600 feet wide, connects two tunnels which open from either side of the gorge. The construction of this portion of the railway was on a gradient of 1.9 per cent, and there is a curve of 4 per cent between the two tunnels. The bridge, which was built by the Société des Constructions des Batignolles, consists of a main span of 262 feet rising 78 feet, and five latticed trusses, each 86 feet in length. Four of the trusses are on one side of the arch, and the remaining one on the other. Three of the four trusses are supported on masonry piers, the fourth resting partly on the third pier and partly on the upper portion of the arch. The fifth truss is supported on the other side of the arch and the entrance to the tunnel. The arch is constructed of two trussed ribs which are hinged at the springing and at the crown, and the arch ribs are riveted trusses. All the steel work was built at shops in Paris.

SUBSTITUTES FOR RUBBER.

ARTIFICIAL COMPOUNDS.

THE present demand for India-rubber naturally directs attention to those articles which, to a greater or less degree, may serve to replace rubber in its industrial applications, and so help in conserving the supply.

Of such articles a very large number have been proposed. Those in actual use to any considerable extent are, however, relatively few. For present purposes the various surrogates may be distinguished as (1) rubber-substitutes proper, consisting wholly of ingredients other than rubber; (2) composite or "artificial" rubbers, which contain a certain proportion of natural rubber worked up with other substances; and (3) true synthetic rubber, namely, a product containing the rubber molecule synthesized in the laboratory or factory by chemical means from simpler compounds.

At present the first of these classes is commercially the most important. Scores of recipes are in existence, including very diverse ingredients; but the basis of most is a modified oil. At first sight there seems little suggestion of India-rubber in the properties of an ordinary vegetable oil, but a simple experiment will indicate the kind of modification which certain oils readily undergo, and which help to fit them for use as rubber substitutes. If we test the drying properties of boiled linseed oil by spreading a little of it over a slip of glass and allowing it to dry, a film of oxidized oil is eventually obtained, having a certain modicum of toughness and elasticity. The liquid oil has taken up oxygen, and thereby become converted into a more or less elastic solid. Tung-oil substitute is essentially such an oxidized product, manufactured by heating the raw oil until it has absorbed enough oxygen to cause it to thicken and become solid on cooling, when it is powdered and worked up with a little petroleum.

In a somewhat similar way the oils can be made to take up sulphur, becoming thereby solid, and endowed in some degree with elastic properties. The treatment is analogous to the "vulcanization" of rubber. "Brown" or "black" substitutes are manufactured by heating the oil with sulphur, a process corresponding to the "hot cure" method of vulcanization. "White" substitutes may be made by merely mixing the oil, cold, with 20 to 40 per cent of sulphur chloride; or, better, by first dissolving the oil in a suitable solvent such as carbon tetrachloride. This resembles the "cold cure" process used in vulcanizing rubber. Colza oil is largely used for these purposes, but various others are available—linseed, maize, arachis, and castor oils, for example. The chemical reaction involved is a somewhat complicated one, but probably it consists mainly in the formation of what chemists term an "addition-product." The proportion of sulphur taken up by the substitutes varies rather widely, ranging from 5 to upward of 15 per cent. As would be expected, oils which have previously been oxidized to a notable extent (e. g. "blown" oils) require less sulphur to saturate them than do the natural oils.

"Nitrated" oils are also used as the basis of some rubber surrogates. Thus one well-known product is a solution of a nitro-cellulose in linseed or castor oil which has been nitrated by treatment with a mixture of nitric and sulphuric acids. Other such articles are made by oxidizing the nitrated oil with lead peroxide, or by simply heating it in air.

These oxidized, sulphured, and nitrated oils, in one form or another, are largely used as substitutes for rubber. Of the other substitutes proposed, a few examples may be given, to indicate something of their general nature.

First there are those which, while still retaining oil as one ingredient, include also other important constituents. Thus, "Fenton's rubber" is a mixture of oils with tar, pitch, and creosote; which mixture, when digested with nitric acid, gives a toughened mass, and this on heating yields an elastic product simulating rubber. "Russian" substitute, said to be useful for covering telegraph cables, contains as ingredients wood-tar, hemp and linseed oils, ozokerite, spermaceti, and sulphur. "Oxolin" is made by impregnating fibrous material such as jute or hemp with linseed oil, oxidizing the oily mass with warm air, and working the product up between rollers into a coherent mass, which can then be vulcanized by heating it with sulphur.

In another category of substitutes, oil plays only a subordinate part, or is altogether dispensed with. Thus "Jones's substitute" is stated to be made from various gums and gum-like products as the chief constituents. In W. H. Perkin's patent (23,031/07), gelatine or glue is dissolved in creosote and then treated with some reagent—potassium bichromate, formaldehyde, or tannic acid—which will render the gelatine or glue insoluble; after "setting," the mass obtained is digested with acetone to make it firmer. "Textiloid" has for its ingredients various resins, nitrocellulose, and camphor. As a curiosity in this class may be mentioned "grape rubber," produced from the skins of grapes by means of pressure; it is not, however, a commercial article. Finally, though this can only be a substitute for rubber in very hard articles, we may mention the interesting material, "bakelite," recently introduced by Dr. L. H. Backeland. It is a condensation-product of formaldehyde and phenol, which can be molded as desired, and afterward hardened.

In what sense are the foregoing articles and their likes to be considered as "substitutes" for rubber? Some persons are disposed to deny them any right to the title, and would look upon them as mere adulterants whenever used partially to replace rubber in what would otherwise be an all-rubber article. Others admit, though sometimes grudgingly, that there is a place which such substitutes can usefully fill. Much depends on what the article is sold as, and on what use it is to be put to. Not all the special qualities of rubber are wanted in all the products for which it is employed. A door-mat is one thing, a bicycle tire quite another. Where a high degree of elasticity is not really needed, as, for instance, in waterproof goods and electrical insulating work, there is a legitimate field for substitutes which may serve the required purpose. Even here they may not be equal to rubber, but they find their justification in their lower cost. After all, we do not need razors to cut sticks with.

It may be said at once that no substitute is equal to rubber in every respect. Chemically, the latter is a very inert substance—much more so than the substitutes. Hence, even if the latter were not otherwise inferior, they would be less durable than rubber under certain conditions. They are nearly all acted upon more or less readily in circumstances where rubber remains unharmed. The modified oils, in fact, are still oils in the sense that they remain glycerides, decomposable by alkalies, as also by steam under pressure. If used for articles exposed to these agencies, they fail in durability, whatever their excellences otherwise.

The fact that substitutes of this class are readily saponifiable by alkali makes it an easy matter to detect them by analysis when compounded with true rubber. As a rule, the proportion of substitute used is from 5 to 25 per cent, and even the small quantity is recognizable.

Of the composite rubbers (or "artificial rubbers," as they are sometimes called), one preparation, which has been made in quantity, and is said to be excellent for many purposes, has for its basis Guayule rubber incorporated with certain gums. Another such article is compounded of natural rubber and some other substance of vegetable origin, probably a latex or a gum, reputed to contain the same chemical elements as rubber and in much the same proportion. Such articles are, of course, only partially "substitutes" for rubber, and their cost rises with that of the latter ingredient. Moreover, if any very large demand for them arose, there is always the possibility that the supply of gums and latices would become insufficient, and the advantage of lower cost would thus tend to disappear.

Coming now to true synthetic rubber; a question often asked is whether there exists any probability of such an article being manufactured and displacing natural rubber, either wholly or to any large extent. Will rubber plantations go the way of madder fields and indigo cultivation? Well, the future is on the knees of the gods. In the face of the precedents just mentioned, to say nothing of others, he would be a bold man who would venture to say that even the best quality of rubber may not some day be made on a commercial scale from cheaper materials such as beet sugar and calcium carbide. But the day is not yet. There are beginnings; there are clear indications of the direction in which to proceed; there is distinct progress to note. But there is still some distance to go, and the end of the journey may not be even in sight.

India-rubber chemically is essentially a polymerized terpene. An article patented some time ago, and named "turpentine rubber," appears to foreshadow a synthesis of true rubber. Turpentine is a mixture of terpenes, and the article in question was to be obtained by passing turpentine through a hot tube, and treating the resulting vapors with hydrochloric acid. The result is a solid condensation-product; and the idea at the base of the process appears to be the production of polymerized terpenes having some of the elastic properties of rubber.

A more promising, because a more scientific way, is that outlined in Heinemann's patent No. 21,772 of 1907. Here a true synthesis is attempted. It is based upon the well-known fact that rubber is probably a polymer of the semi-terpene isoprene. The first step is the production of the unsaturated hydrocarbon divinyl, CH_2: CH.CH: CH_2. This is obtained by passing mixed acetylene and ethylene gases through a heated tube. With methyl chloride, divinyl yields isoprene [methyl divinyl, CH_2: $C(CH_3)$.CH: CH_2]; and the isoprene on treatment with strong hydrochloric acid is converted by a union of molecules into a substance closely resembling caoutchouc, if not identical with it. The raw materials, so to speak, are thus acetylene, ethylene, and methyl chloride, which are themselves obtained by any of the ordinary methods, e. g. from calcium carbide, alcohol, and beet sugar residues respectively.

The question is, can this or some other comparatively simple synthesis, theoretically quite possible as a laboratory operation, be translated into a practicable and profitable mode of manufacture on a large scale? One of the first doubts to arise is whether the synthesized caoutchouc will have the physical properties of natural rubber; or whether these, by any course of treatment, can be imparted to it. This doubt resolved, there comes the question of economical production in competition with the natural product. Much time and thought have been spent on the problem of synthetic rubber, and it is safe to conclude that there will yet be many a headache before it is solved. Judging by what is known to have been done rather than by the promises, rubber planters may for the present sleep peacefully in their beds.—Nature.

The recent disastrous accident on the Canadian Pacific Railway, the fatalities in which were augmented by the fire occasioned by the gas used for lighting the carriages is, according to the Electrical Review, evoking the liveliest expressions of disapproval in Austria, as regards both the use of gas on trains and the official ignoring of the claims of the electric light. In four recent railway accidents on the Continent, the death roll was increased by the fires which ensued, occasioned by the ignition of the gas from the carriage lighting apparatus. Notwithstanding this, the Ministry of Railways is steadily proceeding with the introduction of the incandescent gas system on all the State Railways, which are expected to be completely equipped with this system of illumination by the end of 1914. Two members of the State Railways Council—Herren Rosche and Kareis—have moved resolutions and taken other action in the Council in favor of the substitution of electricity for gas on the State Railways, and it is very unlikely that the government can long ignore the drift of public opinion in this connection. It is noteworthy, our contemporary states, that electric light is already provided on the Nord Bahn and the Aussig-Teplitzer, and the Buschtiehrader railways, and on the Royal Mail trains, where its use is being extended, so that the official railway world is not without practical acquaintance with its advantages.

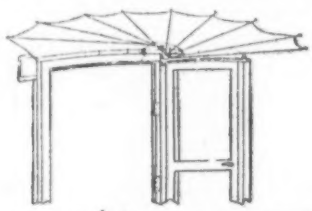
According to Concrete a separate unit type of reinforced concrete wall construction was used last year in building the power-house of a small hydro-electric plant at Newton Falls, Ohio. The pilasters are of monolithic concrete, while the walls between them are hollow and are built of inside and outside thin concrete slabs, which were set before the pilasters were poured, so as to be keyed into them. The slabs were reinforced with No. 28 gage expanded metal, and were made in sizes that could be handled conveniently. Their outer surfaces were corrugated by laying ⅝-inch round rods in parallel lines on the surface of the fresh concrete when the slabs were cast and pulling them out after the mixture had taken its initial set. These corrugations were designed to give a good bonding surface for the plaster coat which was applied to the walls after they had been erected. The slabs were allowed to cure and were then placed on edge in proper position. Vertical form boards were placed for the pilasters, extending beyond the surface for the monolithic work, so that the slabs rested against them. The inside faces of the pilasters were molded against form boards placed in the air space between the wall slabs, and were wired to the outside forms after the pilaster reinforcement had been placed. The inside boards also acted as spaces to keep the slabs the proper distance apart. This distance varied somewhat, but 8 inches was the minimum.

MECHANICAL ODDITIES.*

CLEVER INVENTIONS.

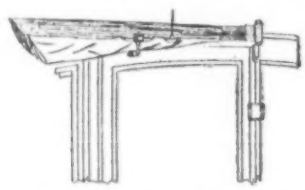
AN UMBRELLA FOR CARRIAGE DOORS.

It is almost impossible to alight from a carriage in a shower without getting wet, for there is always a hiatus between the shelter afforded by the carriage



UMBRELLA FOR CARRIAGE DOORS OPENED.

and that which is offered by the umbrella, which cannot be opened inside the vehicle. A French inventor has devised a peculiarly shaped umbrella, which is attached to the carriage, over the door, and which is spread out like a fan by the opening of the door, so

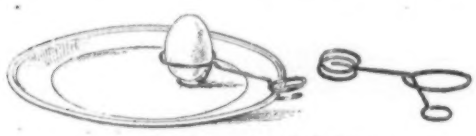


UMBRELLA FOR CARRIAGE DOORS CLOSED.

that it forms a roof which shelters the passenger during and after alighting. The device can be attached to the carriage, very quickly and easily, in rainy or threatening weather, and removed when there is no occasion for its use.

A SIMPLE EGG HOLDER.

For some inscrutable reason egg cups, and especially their bases, are invariably made too small, so that children and maladroit adults often overturn them, thereby wasting good food and soiling the table cloth. A wise Frenchman has hit upon the happy

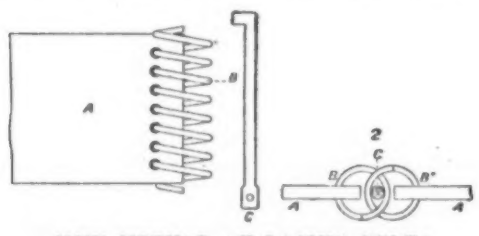


A SIMPLE EGG HOLDER.

idea of dispensing with the egg cup and substituting a piece of iron wire, with one end bent into a double ring which holds the egg securely, and the other end bent into a helix, the spires of which firmly grip the edge of the plate, as shown in the illustration.

NEW METHOD OF LACING LEATHER BELTS.

An original and very practical method of joining the ends of a leather belt has been devised by a French automobilist, whose car is lighted by electricity produced by a dynamo which is connected with the motor by a belt. The difficulty of removing and replacing a sewed belt led to the invention of the new method of joining the ends. The junction is effected by means of an iron pin, *C*, and two spiral



NEW METHOD OF LACING BELTS.

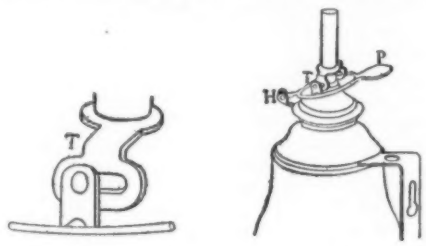
wire springs, *B* (see accompanying diagram). The springs are 2/5 inch in diameter and their length is equal to the width of the belt, when they are stretched so that the distance between adjacent turns of wire is 1/8 or 1/10 inch. After being thus extended, the springs are covered with rouge and pressed on the belt, with 1/8 inch of each end. Each turn of wire marks a red dot, and care is taken to make the dots on one end of the belt alternate with those on the other end. One end of the belt is then perforated at each dot, and one of the spiral springs is passed through the perforations, in the manner illustrated in the left-hand diagram. The second spring is attached to the other end of the belt in the same manner. The ends of the belt are then brought together, so that the springs interlock, and the pin is inserted in the space inclosed by both springs, in the manner shown in the right-hand diagram. The tension of the strap is usually sufficient to keep the pin in place, but for greater security the end of one of the springs may be passed through a hole in the end of the pin. This very simple method deserves to be adopted on all automobiles which have dynamos driven by the motors, by means of belts.

* La Nature.

LAMP WITH INSTANTANEOUS REGULATOR.

The ordinary kerosene lamp is regulated by means of a rack which raises or lowers the wick, but this device sometimes fails to work perfectly, particularly when the wick is not long enough to reach the bottom of the oil pot. In some lamps, the exposed portion of the wick can be lengthened or shortened, and the flame regulated by raising or lowering a tube which surrounds the wick holders. F. Jouve has constructed a lamp of this type, in which the regulation can be effected instantaneously and, if necessary, with the same hand in which the lamp is carried.

As the illustration shows, the lower end of the



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LAMP WITH INSTANTANEOUS REGULATOR.

sliding tube carries a loop (*T*) which engages with a pin in the middle part of the lever, *HP*, which turns on a pivot at *H*.

The lever is so placed that its free end (*P*) can easily be raised or lowered, and the lamp regulated, by the thumb of the hand which grasps the handle of the lamp. In addition to various other uses, this lamp should be of service to photographers, who often require to begin developing a plate with a very faint red light and to increase the illumination as the image becomes visible.

A CIGARETTE SAFE.

Cigarettes kept in an open box often disappear with surprising rapidity, leaving neither smoke nor ashes. This phenomenon is not observed when the cigarettes

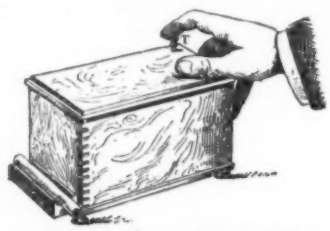


FIG. 1.—CIGARETTE SAFE.

are kept in a secret box, or safe, which can be opened only by the owner. A French inventor has devised a safe which need not be opened every time a cigarette is wanted. By pressing a button a drawer is

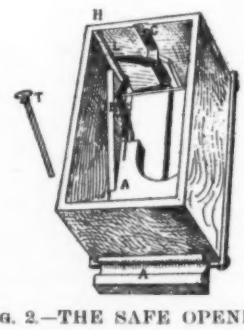
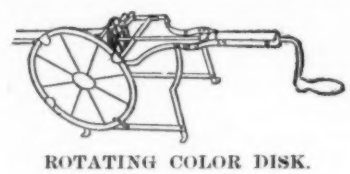


FIG. 2.—THE SAFE OPENED.

caused to open and present one cigarette (Fig. 1). The simple mechanism of the box is shown in Fig. 2. The cigarettes rest on an inclined plane, above the drawer *A*, in the front of which, at the base of the inclined plane and at the end of the box opposite to the push button *T*, is a groove which is just large enough to contain one cigarette. When the button is pressed, the rod to which it is attached is forced downward, through the tube *H*, until it strikes the bent lever *B*, by which the drawer carrying the single cigarette is pushed outward. When the finger is removed from the button, the drawer is closed by a spring and another cigarette rolls into the groove. To insure the safety of the cigarettes, it is merely necessary to remove the button and its rod, which are not fastened in any way. When it becomes necessary to open the box, in order to refill it, an oblique pressure is applied to the button, causing the rod to slip past the lever *B* and strike the lever *L*, which opens the catch *C*, by which the cover of the box is fastened. When the cover is closed, this catch is locked by a spring.

ROTATING COLOR DISK.

It is difficult to give young pupils an understanding of the manner in which the superposition of two colors produces a third color. The physical laboratories of universities possess the apparatus required for

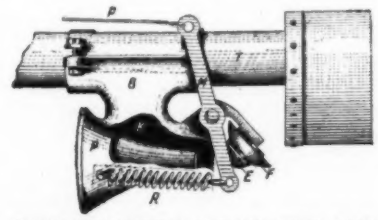


ROTATING COLOR DISK.

these demonstrations, but the primary school teacher is often thrown upon his own resources and compelled both to construct and to turn, with his own hands, the color disks by which the laws of the composition of colors can best be illustrated. A very simple apparatus, which is both interesting as a toy and useful as a means of instruction, has lately appeared in Paris. It consists of a metal frame carrying a multiplying train of geared wheels, which transmit power from a crank to an arbor, upon which various color disks can be fastened. A set of color disks accompanies the apparatus.

NEW EXHAUST APPARATUS FOR AUTOMOBILES.

The smoke-suppressing exhaust apparatus for automobiles herewith illustrated has been found very efficient. It consists of a hollow cast-iron vessel *b*, which is fastened over a hole in the exhaust pipe by two iron bands and which contains a funnel *p*, the mouth of which is directed forward. The after ends of the funnel and the chamber *B* can be closed simultaneously by two concentric clack valves, *e* and *f*, operated by pulling the cord *p*, attached to the lever *NE*. When the cord is released the valves are opened by the spring *R*. When the valves are open, the draft of air through the funnel produced by the forward motion of the car is increased by the aspirating action of the exhaust gases, which flow backward through the space *K* around the funnel. The hot products of



NEW EXHAUST APPARATUS FOR AUTOMOBILES.

combustion are thus immediately and intimately mixed with a large volume of air, and the smoke is almost entirely suppressed.

The value of picture postcards to an engineer may not appear very marked at first thought, but in a paper before the municipal engineers of the city of New York on improvement of the appearance of municipalities Mr. Charles W. Leavitt, Jr., stated that many valuable hints as to the design of structures from the æsthetic point of view might be gained at a very small expense from a study of the French, Italian, and Austrian postcards. He advised all engineers engaged in the design of public works to form a collection of these cards, on account of their information regarding harmonious and pleasing design. While in Paris he obtained several thousand cards showing views of the French streets, parks, lamp posts, bridges, buildings, drinking fountains, and other structures which help to make or mar a city's appearance, and these cards have been of considerable assistance to him in his practice in America by furnishing suggestions for the treatment of public works.

THE DESIGN OF AEROPLANE MOTORS.

A CRITIQUE OF ENGINES.

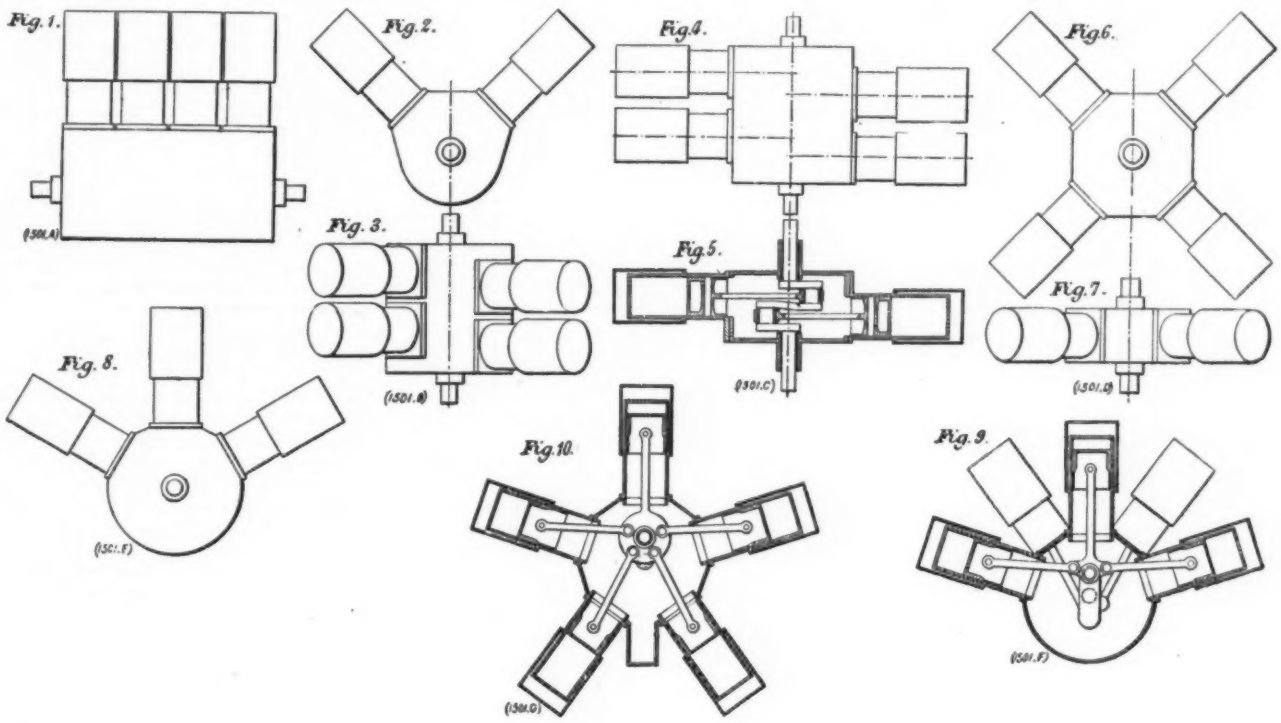
THE advent of the aeroplane has created a demand for internal-combustion engines of extreme lightness, and to meet this there have been produced a set of designs differing in many ways from any previously used. It is therefore interesting to consider to what extent the requirements of an aeroplane differ from those already satisfied by existing light motors, and how far the ordinary engine must be modified to comply with them.

Comparing the aeroplane with the motor car and motor boat, it is evident that, while lightness is desirable for the latter two, it is an absolute necessity for the former—that is to say, a motor car or boat with a heavy engine will, at all events, progress at a certain speed, though not so well as if the motor were lighter; but an aeroplane will not fly at all unless the weight of the motor be kept down to a very moderate amount. In practice, in the motor boat and car, engines are nearly always, for obvious reasons, made as light as they can be, consistent with their fulfilling other requirements, such as durability and reliability. Generally speaking, however, lightness and durability are opposed qualities, and the more reliable a machine is required to be, the heavier it must be also. Hence in any particular case the extent to which lightness can be sacrificed to each trial. If, however, the aeroplane is ever to be of the slightest practical use, the reliability of the engine must not only be brought up to that of the racing car, but very much beyond it. In one important respect the aeroplane engine is much more like the boat engine than the car engine, as it must maintain its full power the whole time it is running, whereas the car engine seldom averages more than half its maximum, except on a track.

The greatest difference is, however, that the boat and car engines must be made so that they can be got at in place, and are practically only accessible from the top, whereas the aeroplane engine can generally be got at from all round. Thus the only practicable arrangements of cylinders in the boat are the vertical and diagonal, and in a car perhaps, in addition to these, the horizontal, while in a flying machine radial arrangements of cylinders are permissible.

Taking the question of the number of cylinders first, there is a very great diversity of opinion, the actual number used varying from two to sixteen. Weight being the most important factor at present, the main question is, What number of cylinders will give the lightest engine, a constant factor of safety being, of course, assumed?

Considering this from a theoretical standpoint, the



durability, or *vice versa*, depends on the purpose to which the machine is to be put.

The case most akin to the aeroplane is that of the racing boat or car. In the latter case the car is only required to run one or two races, and is then put on the scrap heap, and the problem is therefore simply to make an engine which will last this time and develop the maximum possible power for the period. A great many cars have been built in which the limit of size was simply a weight limit, and it may be taken for granted that the winning cars represented the lightest possible construction consistent with the required reliability. In motor boats the same thing applies, winning being almost entirely a question of weight and horse-power. In both these cases money has been of far less importance than it is likely to be in the case of the aeroplane. It will, therefore, be seen that the problem of a light engine is nothing new.

There are, however, several essential differences between the requirements of a car or boat and those of an aeroplane. In the first place, the aeroplane builder appears, at present, to be willing to put up with much less reliability than the racing-boat man. This is because in making records the start takes place when the motor is ready, whereas in a race it takes place at some determinate time; and if the motor be not ready, then the chance is lost. The record is also the result of frequent trials; a race is gained or lost in one. Thus if one motor will make an aeroplane fly 50 miles whenever required and without unreasonable tuning up, but another makes it fly 100 miles once out of ten tries, the latter takes the record, though on its nine failures it may have broken down in a few miles, and may have required hours' tuning up for

matter depends to a certain extent on the arrangement of the crank case, some arrangements being more favorable to a large number of cylinders than others. The actual weight of the cylinders themselves seems, for moderate powers, to be little influenced by their number. The whole question is, How far the revolutions are limited by the size of the cylinders? If a constant piston speed be assumed, the power of cylinders of different sizes only increases approximately as the square of their linear dimensions, while the weight increases as the cube. If run at constant revolutions, however, the power and weight would both increase as the cube. In practice, it appears from the results obtained from racing engines that the possible revolutions are nearly constant for all engines up to 10 inches stroke, at all events, and that the power increases at least as the cube of the linear dimensions. This being so, the weight of the larger cylinder should be less in practice for a given horse-power than that of a greater number of smaller ones, as it will be difficult to reduce the thickness of the cylinders in proportion to the reduced dimensions; and, even if this be done, there are some parts, such as the water jacket, etc., which it will be quite impracticable to reduce with the dimensions of the cylinder.

In practice there is also the fact that on the whole it is much easier to make an engine with a few large cylinders run well than one with a very large number of small cylinders—that is to say, the latter type is much more liable to have fits of running badly. Hence in the long-distance road races the engines with more than four cylinders have had very little success, and in many cases in the smaller classes two-cylinder, and even one-cylinder, engines have been most successful. In motor boats the same thing applies to all powers under about 100 horse-power. Less than two cylinders can hardly be used owing to the difficulty in balancing, but the two-cylinder opposed engine seems a quite satisfactory arrangement. The three-cylinder engines used on the Blériot aeroplanes have also done well.

A point in which the multi-cylinder engine is distinctly superior is the evenness of turning moment. With less than four cylinders some sort of fly-wheel is necessary, though where the propeller is direct coupled it also serves as a fly-wheel. Four cylinders theoretically will not run at all without a fly-wheel, as the drive is not continuous, but with six or more cylinders the drive becomes continuous. While this should be a distinct advantage to the transmission gear, it must be remembered that with many cylinders there is always a great liability for one of them to cease firing, in which case the reversal of stress is nearly as great as with fewer cylinders.

With an ordinary arrangement of cylinders, therefore, it seems as if there would be no advantage in substituting a large number of small cylinders for a few large ones. Capacity for capacity, the large cylinders should give more power and weigh slightly less, while the accessories, piping, etc., should weigh very distinctly less. There are, however, several arrangements by which a large number of cylinders may be grouped on to a very light crank case, and this may produce a light engine owing to the saving in weight in the latter. The weight of an engine consists principally of the cylinders and pistons on the one hand, and the crank chamber, crank shaft, etc., on the other. Roughly speaking, with any given arrangement of cylinders, the weight of the latter will be proportionate to the cube of the dimensions. That is to say, that if the cylinders are arranged vertically in a row, for instance, the weight of the crank case, shaft, etc., will be practically proportionate to the cylinder capacity. If we can mount the cylinders in such a manner that we can get a great cylinder capacity with a very short crank case, we shall, however, save weight. If, for instance, we start with the vertical four-cylinder engine of the ordinary type, as shown in Fig. 1, on the previous page, the crank case has necessarily to be as long as the length over the cylinders. In this and the accompanying figures the valves are omitted for the sake of clearness, and in all the figures the cylinders are the same size, so that the size of crank case necessary for a given cylinder capacity can easily be seen.

Two common plans for reducing the length and weight of the crank case are to place the cylinders either diagonally, as in Figs. 2 and 3, or horizontally opposed, as in Fig. 4. In either of these arrangements the length of the crank case, etc., is almost halved, and a considerable saving of weight is effected. Either of these arrangements can be made with two, four, six, eight, or more cylinders. In the case of the

diagonal engine the impulses are not evenly divided with two or four cylinders, though they can be so with six, if the angle between the cylinders be made 120 deg. With eight cylinders at 90 deg. the impulses are evenly divided, and this is the most usual number. In this type each diagonal pair of cylinders is connected to one crank. The diagonal engine, with the cranks at 90 deg., can be balanced for all practical purposes, even where there are only two cylinders, by placing a balance weight opposite the crank equal to the weight of the whole rotating parts and the reciprocating parts of one cylinder. With four cylinders the cranks are usually placed opposite, but balance weights are still necessary to avoid a rocking moment. With eight cylinders the cranks are set so that the two end ones are opposite to the two middle ones, and no balance weights are required.

In the case of the opposed horizontal engine the two connecting rods work on opposed cranks, as in Fig. 5. In this case the engine, even when the two-cylinder, is in many ways better balanced than the vertical or diagonal types, as the errors in balancing, due to the angle of the connecting rods, is allowed for. If only two cylinders are used, there is, however, a very small rocking moment, due to the fact that the cylinders are not actually opposite each other; but this is usually a negligible quantity. It has in some cases been eliminated by putting the cylinders exactly opposite, and the connecting rod out of line with the little end; but this remedy seems worse than the disease. With four cylinders the rocking moment is balanced. The impulses in the horizontal opposed engine are always evenly divided, whether two, four, or eight cylinders are used.

Comparing the horizontal opposed with the diagonal engine, the former appears to have all the advantages, as the impulses are more even with a small number of cylinders, and the balance better. The latter point will enable somewhat shorter connecting rods to be used without excessive vibration, thus lightening the engine. It seems, also, a distinct advantage of the horizontal opposed engine that the two cylinders can be connected by bolts running right through from the flange of one cylinder to that of the other, and thus the whole of the crank chamber can be in compression and be made much lighter than if any of it had to bear tensile stresses.

While the crank case, etc., is distinctly lightened by these arrangements, it can be still more reduced if the cylinders are all arranged radially on to one crank. This has been done in a great many different ways by different makers. In order to compare with the previously-mentioned four-cylinder engines, a four-cylinder radial engine is shown in Figs. 6 and 7, the cylinders being the same size as before. It will be seen that in this case the crank case and shaft are very much shorter and lighter than in any of the previous arrangements. In practice four cylinders is not a good number, as the impulses cannot be evenly divided, and an odd number of cylinders must be used to effect this. This type of engine can be satisfactorily balanced as long as the cylinders are evenly spaced round the crank case, for all the pistons are attached to one crank pin, and therefore form one revolving weight, which can be balanced by a suitable balance weight.

While this type seems theoretically the lightest, there are several disadvantages to be overcome in making it satisfactory. In the matter of weight there is the difficulty that if the cylinders are water jacketed, each cylinder must have a separate jacket and water connections. Where there are several cylinders close together and parallel, they can all be inclosed in one water jacket, and this will be lighter than taking a separate jacket round each cylinder, while it will also only require one set of water connections. In this the ordinary vertical engine has a very distinct advantage. The diagonal and opposed engines can, however, have all the cylinders on one side inclosed in one jacket, but the radial type must necessarily have them all separate. Numerous water connections not only weigh a very considerable amount, but also introduce more chances of breakdown through failure. On the other hand, if air cooling be used, the radial type is far the best, for the cylinders are so far from each other that they will not radiate heat to each other, and they do not screen each other from the draft of the propeller.

Where many cylinders are used it is impracticable to actually put all the connecting rods to work onto one crank pin, as either the big ends would have to be very narrow, or the crank pin impracticably long. This can, however, be got over by the arrangement shown in Fig. 10.

Probably the greatest difficulty in making the radial engine satisfactory is that of lubrication. This is a matter which does not seem to have had nearly as much attention paid to it as it needs, and many of the aeroplane engines rely solely on splash for their lubrication. In this case the even distribution of the oil to the various cylinders of a radial engine is very difficult, and further, however well it might be managed when the engine was running, directly it stopped the oil would all run into the lower cylinders, and probably foul the plugs, so that it would be difficult to start it again. In order to get over this, the engine has occasionally been laid on its side, with the crank shaft vertical, driving the propeller through bevel gear. If it is desired to run the propeller slower than the engine, there is no great objection to this, and there is little doubt that the slow-running propeller is much the more efficient. Another plan is to modify the arrangement of the cylinders. Thus in one make of three-cylinder engine the cylinders are all at the top of the crank case (Fig. 8), all the connecting rods leading on to one crank pin. In this case it is impossible to divide the impulses evenly, and the balancing is not so good. In practice this type of engine is made with inside fly-wheels of considerable weight, and runs well, but the fly-wheels necessarily add to the weight. Another plan is to put all the cylinders at the top of the crank case, and to place those which would have been at the bottom in a complete radial engine on a crank opposite to the others, as shown in Fig. 9.

A comparison of this arrangement with Fig. 10 will show that it is really a five-cylinder radial engine with the two bottom cylinders moved to corresponding places at the top of the crank case and attached to an opposed crank. The division of the impulses will be the same as in the complete radial engine, and the balancing nearly as good; but the crank shaft must be larger in diameter, owing to its weaker form, and as both it and the crank case are longer, they will be considerably heavier. The cylinders are also so close together that air cooling will be much less effective. Even with all the cylinders above the crank case it does not appear that splash lubrication will distribute the oil at all evenly to all the cylinders. The action of the crank pin or fly-wheel will be to produce a flow of oil round the crank case, and the first cylinder will obviously intercept the greater portion of this. No doubt if enough oil be used, there will be a good deal distributed indiscriminately by the crank pin, etc.; but this will not prevent the first cylinder getting more oil than the others.

Considering the fact that aeroplane engines are run at very high revolutions and that the bearings have to be as small as possible to save weight, it seems certain that they should be fitted with a good system of forced lubrication, whatever their arrangement may be. In this case there seems no reason why the complete radial engine should not be perfectly successful, as the cylinders are lubricated by oil thrown out of the crank pins, and this will be distributed evenly. Fig. 10 shows a five-cylinder engine so arranged. In this case the oil which comes out of the bearings and big ends should mostly fly onto the walls of the crank case and run directly back into the oil sump, while the small amount which goes into the cylinders cannot possibly accumulate when the engine is running, as the speed at which the pistons move is far too high for this. Oil is prevented from running down the walls of the crank case into the cylinders by a projecting rim.

In some cases the radial engine is made with the crank shaft fixed and the cylinders revolving. As constructed by the Société des Moteurs Gnome, this type has given very good results, but it may be doubted whether they are due simply to making the cylinders revolve. A very small amount of consideration will show that the radial engine will be of the same weight whether the cylinders revolve or the crank shaft, all other details of construction being, of course, assumed to be the same. This being so, the only way in which the revolving cylinders can be an advantage is either by allowing a lighter construction of cylinder or crank case, or else by increasing the power got out of a given sized cylinder. There does not seem any reason for supposing that revolving the cylinders secures either of these results.

The advantages of the revolving cylinders are: (1) That they act as a fly-wheel, and (2) that they allow of more efficient air-cooling. Where the propeller is direct coupled, however, no fly-wheel is required in any case. No doubt there is a distinct advantage in the air-cooling from the fact that the cylinders revolve, but it is not likely to be very great.

Assuming that the ends of the cylinders are 15 inches from the crank shaft, and the engine runs at 1,200 revolutions per minute, the ends of the cylinders move through the air at about 95 miles an hour. Now when the engine with fixed cylinders is placed just behind the propeller, it probably always works in a current of air moving 60 miles an hour or more, so it will be seen that the difference is not so great as might be expected. In practice the power given per cubic inch of cylinder capacity by the Gnome engine is very small, and there seems no reason to doubt that the same power could be got with fixed cylinders of smaller size. The good results appear to be due to the fact that the weight of the parts is reduced by machining practically all parts, including the cylinders and crank case, from steel forgings to such an extent that the engine only weighs 0.35 pound per cubic inch of cylinder capacity. It seems probable that with fixed cylinders at least equally good results could be obtained if the same amount of trouble and money were spent. The revolving cylinders introduce numerous difficulties in construction, not the least of which are the effects of centrifugal force on the valves, etc. It is also not so easy to make a neat arrangement of a geared-down propeller.

There are several points of importance in the comparison of these various arrangements, besides the weight. One is that as the length of the crank case is reduced by grouping the cylinders, the work put on the bearings is increased without, in most cases, any proportionate increase in the bearing surface. Thus, if we compare the opposed or diagonal type with the vertical, we see that the former is very much shorter than the latter, but each main bearing in the former has to take the load due to two cylinders instead of one. In the opposed engine this comes on opposite sides of the bearings, so that if the pressure from each cylinder produces the same amount of wear, the slack produced in the opposed engine will be twice that in the vertical. This means that for equal durability the diagonal or opposed engine should have the main bearings twice as long; but in this case the crank case would become as long as that of the vertical engine, and the weight as great. With the radial engine matters are still worse, but in this case the bearings can be somewhat lengthened without actually making the crank case bigger by carrying them out on bosses.

A distinct disadvantage of the radial engine is that it may in some cases not be nearly so convenient to fix as the vertical and opposed, as the latter can have lugs on the crank case, and no parts projecting below this.

On the whole, the type which seems likely to provide the best combination of lightness and reliability is the horizontal opposed, as although the crank case has to be slightly longer than in the radial type, if more than two cylinders are employed, no part of it need be in tension, and therefore it can be very light. Further, for moderate powers the engine can be made with only two cylinders, and this should make it freer from breakdown and more economical in fuel and oil. The more the aeroplane develops the greater will, however, be the importance attached to reliability, and it is quite possible that the vertical type will be eventually preferred, as in racing cars and boats. On the other hand, the radial type is, no doubt, theoretically the lightest; and if the difficulties of making it work satisfactorily can be overcome, it may be the future pattern.—Engineering.

Level-crossing elimination on the railway lines passing through built-up districts in America is so very expensive that the disinclination of railway companies to carry the work out except by instalments, as funds are available for the purpose, is but natural. Some articles by Mr. Greifenhagen now appearing in the Engineering Record illustrate clearly the costly nature of such alteration. In the borough of Queens there are more than 300 level crossings, and in the borough of Richmond there are about 100 of these death-traps. In 1908 there were 29 deaths at such places in Queens, and as the population increases the danger of them must grow. As the law now stands, the Public Service Commission has no authority to compel the alteration of a railway, but must, as specific cases occur, order the street to go above or below the railway, usually at a difficult level. The law provides that the State shall pay one-fourth of the expense, but for years it has made no appropriation for the purpose, and the city cannot pay the State's proportion of the cost without obtaining special legislation. As a result of this condition, level-crossing elimination is practically at a standstill, except where it is done under a special enactment, or the railway company carries out the work at its own expense.

According to the Railroad Age Gazette, some reinforced concrete sleepers which about two years ago were placed in a section of track on the West Pennsylvania lines carrying heavy high-speed traffic do not show signs of deterioration. A ¾-inch steel casing on the sides of the sleeper, with a lap approximately 1½-inch on the top and on the bottom, and eight strips punched out and turned into the concrete serve to hold it in position, while three flat strips across the top and the same number across the bottom are bolted to the sides to prevent spreading. Two longitudinal 1½-inch rods, one near the top and the other near the bottom, provide the necessary reinforcement. The rails rest on, and are fastened to, tie-plates with two 1-inch bolts on each side of the base, the head bearing on the plates inside of recesses on the bottom. To insulate the rails the overlap of the metal sides is sheared off and bent into the sleeper at the tie-plates. These sleepers are 7 inches thick, 1 foot wide, and 8½ feet long. This large bearing area results in a saving of sleepers, as fifteen of them take the place of eighteen of the standard wooden type, and the downward thrust is distributed over a short distance on each side of the tie by rounding the sides slightly.

A SUGGESTED IMPROVEMENT IN AEROPLANES.

VELOCITY AND STABILITY.

BY A. MELIN.

THE aeroplane in its present condition is only an instrument of sport. In order to make it of practical utility, both its stability and its speed must be increased, or rather, it is simply necessary to increase the speed, as increase of stability will follow automatically. The stability of all actual aeroplanes is very precarious, whether it is produced by wings, deformable planes, or without special mechanism. The reason of this instability is that the speed being low the aeroplane is affected by the least disturbance of the atmosphere. A tugboat and a torpedo boat of equal tonnage behave very differently in the same sea, the torpedo boat cutting through the waves and the tugboat being tossed by them. An aeroplane provided with a "feather" would behave in the air like an arrow, on condition that the velocity is sufficient.

This is only one reason, and the least important one, for increasing the speed of aeroplanes. The aeroplane cannot become a useful vehicle until its speed exceeds that of terrestrial vehicles. With the present types we know that in order to double the speed the power must be increased eight-fold. Blériot, in order to gain six miles an hour, was obliged to triple the power of his motor, and in order to gain a little further increase of speed, he found himself compelled to diminish the area of the supporting surfaces.

Let us then assume an aeroplane of small area, designed for a speed of 100 miles per hour. But where can we find a ground on which it can be launched at such speed, and how can we make a landing without the certain destruction of the vehicle and its passengers?

Hence it is absolutely necessary that the aeroplane shall be able to start at low speed and to increase its velocity very greatly during the flight. For the accomplishment of these results the following means suggest themselves: Increase of motive power; diminution of area of sustaining surfaces during flight; diminution of angle of attack. We will dismiss at once the consideration of increase of motive power, for this is not a real improvement, but a last resort. The diminution of area, a solution which is very seductive at first sight, appears on more careful examination to be full of difficulties and dangers. As these surfaces must be made to fold, they will necessarily be deficient in strength and rigidity, and it will also be very difficult to maintain the curvatures unchanged. Furthermore, if the motor stops, the operation required for extending the surface will demand an appreciable time and expense of muscular energy, so that the aeroplane is very likely to strike the ground before the operation is effected. Landing in such conditions would be very sudden and disastrous. Hence this method must be rejected. The diminution of the angle of attack remains to be considered. This, combined with the effacement of part of the sustaining surface, forms the object of the present patent.

Let us suppose a surface divided into three parts *AB*, *BC*, and *CD* (the number, arrangement, and curvature of the parts are, however, variable). Let us suppose that the bow and stern portions, *AB* and *CD*, are kept parallel to each other and make an angle, $a + b$, with the trajectory, and that they produce an upward pressure F_2 and a horizontal resistance H_2. The middle part *BC* makes a smaller angle a with the trajectory and produces an upward pressure F_1 and a resistance to forward motion H_1. These values correspond to a velocity *V* such that the sum of F_1 and F_2 is equal to the entire weight of the apparatus, and the surfaces are so calculated that this velocity *V* is as small as possible, in order to facilitate starting and landing in a small space and without shock. The compound surface *ABCD*, is arranged to turn on an axis at *O*, a short distance behind *T*, the center of upward pressure. By means of a lever or other device, let us turn *ABCD* about *O* so as to make the middle part *BC* parallel to the trajectory. As the points *T*

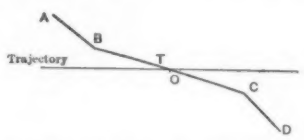


DIAGRAM ILLUSTRATING MELIN'S IMPROVEMENT IN AEROPLANES.

and *O* are near together, the expenditure of energy required for turning the surfaces will be small, and the operation may be effected by several successive stages. In the new position, as the middle surface *BC* is parallel to the trajectory, it does not contribute to the upward sustaining pressure. The resistance of this portion to forward movement will also be negligible if the surface is sufficiently smooth, since this resistance will then consist entirely of air friction. The terminal portions *AB* and *CD*, now make with the trajectory a smaller angle *b*, and consequently their resistance to forward motion is greatly reduced. Hence, without any increase in power, the speed of the aeroplane will increase to a value V_1, greater than its initial value *V*. The surfaces *AB* and *CD* are of such dimensions that the new upward pressure F'_2, which they produce at the new velocity V^1 is equal to the weight of the apparatus, which must now be sustained entirely by these two surfaces. The ratio between these two surfaces is so calculated that the center of pressure shall vary as little as possible during the change in the angle of attack, the small variations which cannot be avoided being compensated by means of the horizontal rudder, which may be removed automatically by the change in the angle of attack.

Thus we have increased the velocity by diminishing the resistance without increasing the motive power, and without affecting the stability and security. In fact, if the aeroplane tends to fall, the middle surface *BC* will again become operative and oppose an upward pressure. Furthermore, as the center of pressure is in front of the center of rotation, if by means of a clutch controlled, for example, by a pedal, the surface *ABCD* is released, it will tend of itself to resume its first position, in which it will produce a great resistance to forward motion, which will reduce the velocity to its original value. In this way, landing can be effected without shock.

It might be feared that in the second position, in which the line *AD*, representing the mean direction of the surface, makes a small angle with the trajectory, a downward air pressure might be produced upon the upper surface. There is no such danger, for the forward position, *AB*, still makes a considerable angle with the trajectory, although the average direction of the entire aeroplane is very nearly parallel therewith. Furthermore, such filaments of air as may strike the upper surface, as designed in my apparatus, instead of producing a downward pressure, will increase the sustaining power. This is the well-known effect of a current of air striking a curved surface tangentially. For further details on this point the reader is referred to Sir Hiram Maxim's work on artificial flight, to Goupil's papers in L'Aerophile, and to the Revue de l'Aviation, February, 1909.

The forward edge may also have considerable thickness, as it has in Wright's aeroplane, which is certainly an excellent one and does not appear to be affected injuriously by air currents striking the upper surface, although the forward portion is so nearly tangent to the trajectory that it appears to fly with a negative angle of attack.

Theoretically, other things being equal, in order to double the velocity by acting only upon the area of the sustaining surface, it would be necessary to reduce the latter to the ratio of 16 to 1. One of the advantages of my device is that I act simultaneously upon the area, by cutting out the middle portion *BC*, and upon the mean angle of attack. Thus, if the sum of the surfaces *AB* and *CD* is equal to one-third of *BC*, and the angle of attack is diminished by one-half, the velocity is approximately doubled without increasing the power.—Aero Mechanique.

A BOX WITH SECRET OPENING.

THE box illustrated in Figs. 1, 2, and 3 is made to resemble a book in shape, and is opened by drawing out a panel in one of its covers. When closed, it is not easy for a person who does not understand its construction to discover how to open it. It requires to be very neatly made, and the wood must be well seasoned, so that it will not warp or shrink and spoil the fit of the loose panel. For the same reason, the smaller it is made, the better, for the panel must not become loose enough to slip out of itself, nor must it be too tight to be drawn easily. The dimensions given on the illustrations represent a convenient size, but there is no reason why they should be strictly adhered to. The choice of wood for the purpose may depend on what is available, but hardwood should be used in preference to soft, and among the common hardwoods, mahogany is the least liable to shrink or warp.

The simplest method of construction is to glue the sides and back on to a block which has had its central part cut out to form the interior space. This block, with the back glued on it, is shown in Fig. 3. In one side of this, a thin piece of solid wood is glued to form one cover of the book, and on the other strips are glued to inclose the loose panel. These strips, which are three in number, leaving one end open, are shown on the upper face of the views in Figs. 1 and 2. As there is a likelihood of the panel becoming a bad fit through shrinkage, it is best to get it out first, plane it nearly to thickness, and leave it to shrink as much as possible before it is fitted. The block to which the outer parts are glued may then be squared up to dimensions, and the hole, which is to be cut through it, marked out on both faces. This may easily be done, gaging lines from the edges and striking the small rod in the corners with dividers. A center-bit hole is then bored through at each corner of the marked-out portion, and the straight parts sawn within the lines. It is then pared through to the lines with gage and chisel, and tool marks removed by glasspapering. Next, a piece for the back is prepared

FIG. 3.

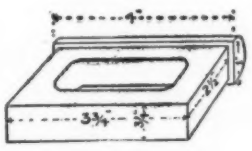


FIG. 2.

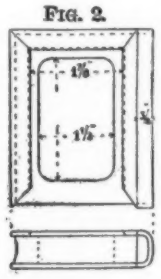


FIG. 1.

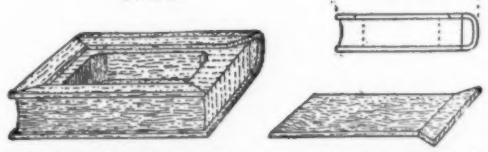


Fig. 1.—View of book with panel drawn out. Fig. 2.—Plan and end view of book with panel removed. Fig. 3.—Block with hole cut through it and back glued on.

and glued on. This must be large enough to overlap about ¼ inch all round, as in Fig. 3, and it is best not to finish it to shape as shown, but allow sufficient for trimming down after the sides or covers are on. Next, a single thin piece of wood about ⅛ inch thick, the full length of a cover and of a width to extend from the glued-on back to about ⅛ inch beyond the front edge of the block, will be glued on one face of the block, thus covering and forming a bottom to the hole which has been cut through. On the other face of the block, three strips with mitered corners form a portion of the other cover, and the remainder of it is supplied by the panel, which slides in. The edges of strips and panel must be veed, so that the panel can only come out by sliding lengthwise. The panel is a single piece of wood, as shown separately in Fig. 1. A line is scribed across its face, where the mitered portion commences, and the cover on the other side of the book is scribed to give the appearance of a similar panel. The covers, however, are not exactly similar in appearance, because on the side where the strips are glued, the grain runs across at one end. This is rather an advantage than otherwise, because it shows the person familiar with it which way it opens, but even when noticed by another, does not solve the puzzle.

The work is finished by gaging the front to a curve, and rounding the back. Each end of the latter is carved out, as shown in Figs. 1 and 2.—Hobbies.

A writer in the American Machinist states that while soft soldering is not considered a very mechanical way of fastening machine parts it sometimes helps one out of a difficulty in a surprising manner. Over a year ago he had to repair a lathe, the main driving gear on which was very loose on the spindle. The spindle was hollow and so thin that it did not furnish a good support for the key. The gear, spindle, keyseat, and key were cleaned and carefully tinned. They were then heated hot enough to melt the solder and assembled. The lathe has been in hard service ever since and the gear is still perfectly tight. He has used this method on other gears and has never had one work loose, although they can be quickly removed at any time with the aid of a blow lamp.

ELECTRICAL NOTES.

A study of the electro-metallurgy of zinc carried on by V. Engelhardt and M. Huth would seem to indicate that the electrolytic refining of zinc cannot profitably be carried on. Copper refining yields valuable by-products in the noble metals; the Friedrichshütte at Tarnowitz tried for some time electrolytically to refine the residue from the zinc desilveration process after Roesing, but it proved too expensive. Hopfner's electrolysis of zinc chloride was not economical either, though technically successful. There remains the sulphate electrolysis. The ore is roasted, extracted with sulphuric acid, the solution purified and then electrolyzed. A good zinc is obtained only from pure solutions. When hydrogen is evolved spongy zinc forms and redissolves in the acid set free. The hydrogen may be oxidized in various ways. The chief trouble is the insoluble anode. Carbon is destroyed. Ferchland's anodes of lead peroxide have answered in an experimental plant in Silesia; but they can be obtained only in rod shape and are not durable. Anodes of manganese peroxide are equally good and have lasted more than a year; no zinc is redissolved even in the presence of 10 per cent of free acid. Even this process, however, depends upon cheap power, the power consumption being high.

At a meeting of the Italian Society for the Advancement of Science, P. Barreca read a paper on the measurement of the power radiated from an antenna. According to him, if W denotes the power which is radiated by an antenna supplied with pure sine oscillations, and I the r.m.s. current at the base, then $W/I^2 = a$ is a quantity which is shown to be independent of the dimensions for antennæ which are geometrically similar. Measurements (of the energy in the primary circuit) are made with and without the sending antenna; the difference represents the energy radiated if that lost in heating the antenna be neglected. The oscillations are derived from a hydrogen arc, across the terminals of which is connected an air condenser of 0.00165 mfd. in series with the primary of an oscillation transformer. The secondary circuit consists of the sending antenna, connected through the secondary of the transformer and a hot-wire ammeter to earth. The watts in the primary circuit are measured by means of a Braun kathode tube with two pairs of electrodes, one pair bridging the condenser and the other the arc. The area traced out by the luminous spot on the screen, multiplied by the frequency ($n = 411{,}000$) and the capacity of the condenser, gives the energy in the circuit. Purity of the oscillations in the secondary circuit is secured by sufficiently loose coupling, in the primary circuit by sufficiently great L/C. The mean of several experiments gives 212 watts with aerial and 111 without, representing 101 watts radiated for a current to earth of 27.2 amps. The value of a for the system used is therefore about 14 ohms, with a possible error of ± 30 per cent.

An electric accumulator locomotive fitted with Edison cells has been built by the firm of F. Schichau for the Prussian-Hessian State Railways, according to the Elektrotechnische Zeitschrift. The length of the locomotive over the buffers is 25.6 feet, and the cells are arranged in the usual manner on each side of the cab in water-tight chambers, with ventilating openings provided with dust filters. The battery comprises 408 Edison cells of the H 45 pattern, with a capacity of 280 amp. hours each, so that the average discharge pressure is 502 volts. The cells are grouped in wooden crates in batches of four. Each cell measures 6.7 inches by 5 inches by 12.2 inches high, and the total weight of the battery, including the wooden crates, is 5.9 tons, or about 32 pounds per cell. There are twice as many positive as negative plates. The plates are spaced only 1.5 millimeter apart, and are separated by thin rectangular hard-rubber sticks. Hard-rubber pieces insulate the plates from the containing case, and the terminals from the cover, which is sealed on. The electrolyte is a 21 per cent solution of caustic potash. The life of both positive and negative plates is said to be 93,000 train-miles. The electrical equipment of the locomotive comprises two series motors, each with a capacity of 35 horse-power on the 1-hour rating, and coupled to the driving axles through single reduction gearing of 1 to 4.44. The motors have series-parallel control, there being five series, four parallel, and one short-circuit braking positions of the controller. On account of the low supply pressure available, the battery is charged in two parts, the cost of a single charge with current at 6 pf. per unit being 18 marks. The total weight of the locomotive is 19.5 tons, made up of 9.8 tons for the body, frame, and trucks, 3.8 tons for the motors and switchgear, and 5.9 tons for the battery. On the test run, this locomotive hauled a loaded goods truck with a total weight of 36 tons over a distance of 212.5 kilometers (132 miles) on one charge, which had lasted 3¾ hours. At the end of the journey, the battery had a terminal pressure of 468 volts, so that it would have been possible to run another 50 kilometers (30 miles). Profile maps of the line are given showing the gradients and the corresponding energy consumption. On the Elbing-Braunsberg section the energy consumption (locomotive and one trailer of 31.5 tons) was 25.2 watt-hours per ton-kilometer in one direction and 18.10 in the other (downhill). On the Elbing-Tolkemit section the figures were 28.0 and 13.4 watt-hours per ton-kilometer respectively.

SCIENCE NOTES.

There are a number of illusions and constant errors of judgment which are well known in the psychological laboratory, and which seem to depend, not on peculiarities of the sense organs, but on quirks and twists in the process of judgment. A few of these have been made the matter of comparative tests, with the result that peoples of widely different cultures are subject to the same errors, and in about the same degree. There is an illusion which occurs when an object, which looks heavier than it is, is lifted by the hand; it then feels not only lighter than it looks, but even lighter than it really is. The contrast between the look and the feel of the thing plays havoc with the judgment. Women are, on the average, more subject to this illusion than men. The amount of this illusion has been measured in several peoples, and found to be, with one or two exceptions, about the same in all. Certain visual illusions, in which the apparent length or direction of a line is greatly altered by the neighborhood of other lines, have similarly been found present in all races tested, and to about the same degree. As far as they go, these results tend to show that simple sorts of judgment, being subject to the same disturbances, proceed in the same manner among various peoples; so that the similarity of the races in mental processes extends at least one step beyond sensation.

Certain phenomena observed by Hale in sun-spot spectra induced H. A. Lorentz to work out the theory of the Zeeman effect on the assumption that the direction of observation is oblique to the lines of force—a problem already treated by W. Voigt, but in which some details remained to be examined. The subject here treated is the "inverse" effect, to which the direct one is intimately related, and the discussion starts with the fundamental equation in the form in which Lorentz gave it in the "Mathematische Encyklopädie," supposing the magnetic field to be homogeneous and parallel to the axis of z. Though, on account of the complexity of its structure, the mode of motion of the electrons in a particle may be far from simple, it is found possible to treat them mathematically in a general way. This is due to the circumstance that, under certain simplifying restrictions, the electromagnetic action exerted by a particle is found to be wholly determined by its electric moment. Hence, in considering the influence of a particle on the propagation of light, it is possible to replace it by a single electron, to which may be assigned an arbitrarily chosen charge e, and whose displacements, x, y, and z, have such values that the products ex, ey, and ez are equal to the component electric moments of the particle. This imaginary electron may be called the "equivalent electron." Mathematical expressions for the oblique field at an angle ϕ are then derived, which, on putting $\phi = 0$ or $\pi/2$, reduce to those of the well-known theory of the Zeeman effect for directions parallel to or perpendicular to the lines of force. Certain special cases are also discussed.

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TRADE NOTES AND FORMULÆ.

Ointment for Burns (Lanolin Ointment).—100 parts lemon grass oil, 100 parts lanolin, 15 parts sugar of lead, 2 parts liquid carbolic acid.

Hardening Preparation for Files.—For sprinkling into a file hardening apparatus, the following mixture is good: Horn meal, 5 parts; wood charcoal dust, 5 parts; common salt, pulverized, 2 parts; nitrate of potash, 0.5 part; ferrocyanide of potassium, 1 part.

For Protection Against Mosquito Bites.—The following mixture has proved excellent: 2 parts thymol are dissolved in 8 parts of alcohol, then 20 drops of oil of cloves added to the mixture. This must be applied by means of a cotton wad, to hands, neck, and face.

Casein Glue in Powder Form.—15 to 20 parts, by weight, of dry refined casein are reduced in a pulverizing mill to a fine flour, and then in a sifting and mixing device thoroughly mixed with 1 to 4 parts, by weight, of ground borax or with 2 to 8 parts, by weight, of bi-carbonate of soda. Much importance attaches to a very careful mixing of the powder.

Asphalt Varnish for Wooden Dishes.—Asphalt 200 parts, dissolved warm in 900 to 1,000 parts of oil of turpentine (best effected in an iron pot, with close lid, in the water bath). When dissolved add 100 parts of elemi, 100 parts yellow wax, 100 parts Venice turpentine. Allow the whole to boil gently for ¼ to ½ an hour, and when cooled strain through a cloth.

To Destroy Crows.—For the destruction of crows, in neighborhoods which they frequent in great flocks, a confection of phosphorus, flour and ox-blood is recommended; strychnine is not to be recommended for this purpose; its effect is too rapid and the crows, seeing the sudden collapse of their fellows, become suspicious and soon avoid the dainty morsels.

To Attach Celluloid to Metal.—The best adhesive for celluloid to metal is, according to experience, 98 per cent acetic acid. It is, however, advisable to immerse the celluloid articles for about 30 seconds in the acid and then, when the upper stratum is somewhat dissolved, to press it on the metal, and, if possible, to subject it for a time to a light pressure. If, however, we wish to make perfectly sure, mix the acetic acid with some celluloid shavings so that a mixture of about the consistency of mucilage is obtained; this insures the closest adhesion of the two substances.

Insoluble Adhesive for Envelopes and Postage Stamps.—Two solutions are required, one to be applied to the inside of the flap of the envelopes, one to the part of the envelope to which this is to stick. The latter solution (which must not be moistened with the tongue) consists of 30 parts of crystallized chromic acid dissolved in 15.5 parts of water and about 15.5 parts of strong ammonia with about 10 drops of sulphuric acid. 31 parts of cupric oxide of ammonia and 4 parts of fine white paper added. First solution: Dissolve isinglass in acetic acid (1 part acid to 7 parts water) at 212 deg. F.

Polish for Pressed Brass Goods.—Substances of a slimy character that are not actually fats, are better suited than soap and are more easily removed from the finished goods. Water and ox-gall, boiled together in equal parts, furnish an excellent polishing material. After cooling, this fluid may be corked up in bottles and when needed used in a glass or porcelain dish. It should be applied with a small brush and the burnishing tool may also be dipped in it. Brass articles can also be brilliantly polished with a mixture of ½ pint of buttermilk and a tablespoonful of common salt. Soak a rag in the mixture and vigorously polish the object. Afterward dry it off and the article will look like new.

TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—Wind Statistics for Aeronauts 265
The Design of Aeroplane Motors 265
A Suggested Improvement in Aeroplanes.—By A. Melin.—1 illustration 267

II. ASTRONOMY.—The Sixty-inch Reflector of the Mount Wilson Solar Observatory.—By E. A. Fath.—4 illustrations 273

III. ELECTRICITY.—An Electro-Magnetic Sounding Apparatus.—By our Berlin Correspondent.—1 illustration 270

IV. GEOLOGY.—Halley on the Age of the Ocean.—By George F. Becker 275

V. MISCELLANEOUS.—The Ancient and the Modern Abacus.—By Daniel Arthur.—4 illustrations 276
The Mechanism of Progress.—By Prof. R. S. Woodworth 279
Mechanical Oddities.—10 illustrations 284
A Box with Secret Openings.—1 illustration 286

VI. TECHNOLOGY.—Modern Stereotype, and the Mechanics of the Newspaper.—I.—By Henry A. Wise Wood.—2 illustrations 280
Substitutes for Rubber 286

VII. TRAVEL AND EXPLORATION.—Sven Hedin's "Trans-Himalaya." 274
Story of the "Pourquoi-Pas."—Dr. Jean Charcot's Account of His Antarctic Expedition 288